JOURNAL OF GAS LIGHTING & WATER SUPPLY.

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VOL. CXXI., No. 2594.] TUESDAY, JANUARY 28, 1913. [65TH YEAR.

EDITORIAL NOTES.

Lighting of Factories Committee—A Protest.

EARLY last week it was officially announced that the Home Secretary had appointed a Committee to inquire and to report regarding the conditions necessary for the adequate and suitable lighting (natural and artificial) of factories and workshops, having regard to the character of the work carried on, the protection of the eyesight of the persons employed, and the various forms of illumination. The names of the members of the Committee accompanied the announcement. They are: Dr. R. T. Glazebrook, C.B., F.R.S., the Director of the National Physical Laboratory, Mr. Leon Gaster, Professor Francis Gotch, D.Sc., F.R.S., Dr. J. Herbert Parsons, F.R.C.S., Mr. W. C. D. Whetham, F.R.S., and Sir Arthur Whitelegge, K.C.B., Chief Inspector of Factories, with, as Secretaries, Mr. D. R. Wilson, one of His Majesty's Inspectors of Factories, and Mr. C. C. Paterson, of the National Physical Laboratory. We are not aware who advised the Home Secretary as to the composition of the Committee; but we do protest most emphatically against the absence of any direct recognition of the gas industry in that composition, in view of the large amount of responsibility of the industry for the lighting of factories and workshops. The terms of the reference are sufficiently comprehensive for both the gas industry and the electricity industry to be represented upon the Committee; but what is found is that, while the former is unrepresented, the latter is strongly represented in the persons of Dr. Glazebrook (the Chairman of the Committee), Mr. Leon Gaster, and Mr. C. C. Paterson. Far be it from us to suggest that these gentlemen will not perform their duties on the Committee in a perfectly impartial and judicial spirit; but the fact remains that Dr. Glazebrook is a member and Past-President of the Institution of Electrical Engineers, Mr. Leon Gaster is a member of that body, and Mr. Paterson is an Associate Member. The other members of the Committee are all men of high scientific attainments; but they are not immediately in touch with the gas industry as are the three members named with the electrical industry. In this, the gas industry has been treated not only unfairly, but, we venture to say, discourteously, in view of its position and the extent of its interests in the country. Had the Institution of Gas Engineers or the Metropolitan Gas Referees been approached, either of these bodies could have nominated a representative for the gas industry of high scientific status. As it is, we hope there will be protest from the bodies representing the technical and commercial interests of the industry in regard to the neglect which the composition of the Committee suggests.

The reference to the Committee, it will be observed, speaks of "adequate and suitable lighting" having regard to the nature of the work carried on. In this connection, practical questions arise which only practical men, in collaboration with scientific men, can deal with; and there again it appears to us there is a deficiency, and therefore a weakness, in the constitution of the Committee. No doubt the extensive and varied experience of Sir Arthur Whitelegge will have weight with the Committee in this regard. The scientific element on the Committee, however, rules; and it is just as easy for a scientific committee to go astray in its findings and recommendations without the assistance of practical experience, as it is for the practical man to go astray without the aid of science. It is further seen that the Committee, in considering the question of illumination, are not only to have regard to the nature of the work carried on in factories, but are to investigate the question of the protection of the eyesight of the persons employed, and the various forms of illumination. This last clause of the reference—"the various forms of illumination"—ought certainly to have suggested the direct representation of the gas industry on the Committee, to see that the interests of the industry were thoroughly considered and protected. A Boys, a Smithells, or a Bone could have well undertaken the representation of the industry, and ranked equally with the three Fellows of the Royal Society who are already members of the Committee.

The clause of the reference as to "the protection of "the eyesight of the persons employed," shows that the inquiry will be in part of a physiological character; and physiologists have a particularly strong place on the Committee. Professor Gotch is Professor of Physiology at Oxford, and one of our most distinguished British physiologists; we might almost say, without anticipating any contradiction, that he stands at their very head. Antecedent knowledge suggests that he will bring an open mind to bear upon the problems that come before him in connection with this particular matter. Dr. J. Herbert Parsons, it will be remembered, read a paper before the Illuminating Engineering Society early in 1910, entitled "Glare: Its Causes "and Effects." He treated in that paper the physical and physiological conditions surrounding his subject; and he then announced himself as firmly convinced that the range of the mechanism of the eye is not sufficiently great to abolish the evil results of intensely high illumination. Mr. Whetham, we believe, is a Lecturer on Physics at Cambridge, and is a Fellow of Trinity College. Although not underrating the importance of the physiological side of the inquiry (indeed, it is most important), the strength of the Committee seems unnecessarily great in this direction, more particularly when the omission of representation in other directions is taken into account. Sir Arthur Whitelegge is, we believe, personally quite impartial in regard to modern methods of illumination. Mr. D. R. Wilson, the principal Secretary to the Committee (to whom communications regarding the inquiry may be addressed at the Home Office), it will be remembered, made an investigation into the lighting of factories and workshops during the year covered by the last annual report of the Chief Inspector; and his report was fully dealt with in the "JOURNAL" last July. Mr. Wilson's method of treating the subject showed that he was strictly independent and unprejudiced in the matter of illuminants.

We repeat that there is no objection on our part to any member of the Committee. Our sole complaint is that the Committee as a Committee of Inquiry (whose findings may have a very powerful effect) is defective through the incompleteness of its composition, and is ill-balanced. Against those conditions we protest; and the protest is made without the slightest disrespect to any of those who have been selected to serve.

The Belfast Illustration.

THE Belfast Corporation Gas-Works are to-day a remarkably fine illustration of the economies attainable by various forms of modern construction—economies affecting site, space, and labour, besides an aggregate of working gains that represent money. What is seen is the end of a long drawn-out controversy as to the extension of the works. This commenced some thirty years ago, when the first report on the matter was made by the late Mr. James Stelfox, acknowledged by all his contemporaries to be of the front rank of engineers who have helped the gas industry along the road to the distinguished position that it now occupies among those industries that minister to the daily requirements of the community. Gas-works extensions have been in Belfast more or less a matter of pressing necessity the whole of this time; and had it not been for the skill of the Engineers who have managed the gas affairs of the Corpora-

tion, we have no hesitation whatever in saying that Belfast would have suffered from the delay in committing themselves to new works. It is not always that, under the congested conditions of gas-works such as those at Belfast, it can be said that the delay in meeting the claims for extensive enlargement, or for construction on a new site, has not resulted in visible and material harm. But there is nothing whatever in the financial position of the undertaking, nor in the service to date to the city, that discloses any injury. On the contrary, we cannot help feeling now that, though the Gas Committee and their advisers were unconscious of the fact at the time, and probably thought otherwise, there was much wisdom in procrastination. It is not always so; and though Belfast has in the event come through safely, we should be very loth to take the responsibility of advising that their example should to-day be followed by others. The circumstances of the years change. The circumstances of the years, it just happens, have changed to the advantage of Belfast, as was seen at the inauguration of the new and reconstruction work, which is the beginning of the complete scheme of alteration to the face and body of the works, due to the grasp of the engineering situation by Mr. James D. Smith. Entering office as the Corporation Gas Engineer as recently as 1910, he was confronted by an imperative necessity and by many limitations; and the present achievement, and the lines of prospective completion, have conferred upon him the greatest honour that he has so far derived throughout the course of his engineering career.

The Chairman of the Gas Committee (Alderman James Craig) made the remark last Monday that "the large ex- "penditure of the present was due to the past years of "inaction." Regarded from the engineering and economic standpoints, under the fortunate circumstances of the department, we congratulate them upon this inaction; for it is only in comparatively recent times that there have been the developments in practice and types of plant which have enabled them—without going to a new site, but with an extension for storage of the present one—to so increase the productive capacity of the old site, that there may be a feeling of perfect security that the question of erecting gas-works on other ground may for some years to come be considered at an end. The expenditure on the section of the scheme that has been carried out may have been large; but the Gas Committee can afford it. It is matter for congratulation that every test that a gas expert can apply clearly shows this. The capital liability is now only £165 per million cubic feet; business has been, and is, increasing; and the price of gas is only 1s. 9½d. per 1000 cubic feet net. If all municipalities, in all their trading undertakings, could show results such as these, the anti-municipalizers would have greater difficulty in maintaining their ground. To say this, is a compliment to the Belfast gas administration, past and present. In considering the expenditure, it has to be further remembered that the favourable financial position is supplemented by the manufacturing gains that will accrue from the investment.

We repeat, the face of the works has been largely changed; and progressively this will continue. Half of a new retort-house has been erected; and the productive capacity of the ground space occupied, through the adoption of vertical retorts on the Glover-West system, places completely in the shade the productive capacity of similar area under the old system of carbonizing plant on the works. Apart from the extended productive capacity of a given unit of area, the views of the local rulers on the subject of industry being conducted without avoidable nuisance have become hardened with time; and they are minded that their own manufacturing establishments shall be patterns to other manufacturers in this regard. Ormeau Road claims that there shall be as great an immunity as possible from nuisance; and Mr. Smith has ensured this, to the maximum extent attainable by present practice, in his choice of plant. The visitors to the works yesterday week were surprised to see the cleanliness of the new retort-house operations, and the absence of smoke, dust, and steam—due not only to enclosed charging and primary discharging operations, but to the fact that the incandescent coke is air-cooled while confined in the lower part of the retort. The advantage of this (conjoined to the other productive and working gains) cannot be set on one side where the preservation of the purity of the local atmosphere is a consideration. The present eighty vertical retorts, in their light steel-framed building, have a productive capacity of 2½ million cubic feet per day; and when, in time to come, Mr. Smith's plans for remodelling the works and establishing the greater modern efficiency are consummated, the plant will have a carbonizing capacity equalling an output of 16 million cubic feet of coal gas a day. There is engineering in these plans; and, contrasted with the old conditions, they show the economy of modern practice and types of plant.

The new retort-settings (erected by West's Gas Improvement Company) were seen yesterday week working well up to the reputation of the system. There is a point that strikes one in connection with the coke removal and distribution from the house. A West conveyor is used inside; while a telpher conveyor is employed for distribution outside—the contractors for this being Messrs. Robert Dempster and Sons (who are also responsible for the new four-lift spiral-guided gasholder, of 3-million cubic feet capacity). Telpher plant—through aerial distribution and preservation of yards from surface transmission, together with its elasticity in the matter of circulation and termini, and its low wear and tear—has been adopted by many engineers in reconstruction and extension work; but it is not possible to utilize it with vertical retorts as with horizontal retorts and side discharge of the coke for removing the material from the retorts to destination in one operation. The under-bench discharge of the verticals necessitates two operations—first removal to a point outside the house, and transmission thence by the telpher system. But this difference in coke removal between vertical and horizontal working is compensated in the continuous vertical system by the air-cooling of the coke, and its preservation from deteriorating fracture and moisture where water quenching has to be resorted to. Above, incidental reference was made to the spiral-guided gasholder. This holder exemplifies a storage economy; for, occupying a tank in which a 1½ million cubic feet holder formerly stood, it has a capacity of 3 million cubic feet. In designing the holder, Mr. Smith has ensured that his factors of safety shall, if anything, err on the generous side—in fact, the contractors acknowledge that they have not been called upon to build a stronger holder of the capacity of this one on the spiral-guided system.

Sufficient has been said to show how the Belfast works to-day illustrate the economies of modern plant structure. We congratulate Mr. Smith upon the relief he has been able to afford his Committee from the dilemma in which they have been for some time owing to the congested state of the works; we congratulate, too, the Committee on their enterprise; and the two firms of contractors must be complimented upon the good opinion won for themselves in Belfast by completing their contracts with satisfaction to the Committee and their Engineer, and with so much promptitude, in face of the obstacles presented by the coal strike.

Calorific Power in Parliament.

It would have been strange if, after the still unended session of Parliament, the immediately succeeding one had not opened with calorific value proposals as part of the legislative programme of the gas industry. The Bills of local authorities reviewed in other columns this week present us with the voluntary schemes of two corporations of position for displacing illuminating power as the standard, and adopting calorific value instead. There is a potential significance about what has happened in this connection. In the gas industry there has been talk of illuminating power being obsolete as a standard, and of calorific value being the standard that best expresses what users of gas require. But the section of the British gas industry represented by companies (who have usually headed new movement) has been slow to take the first step in effecting the change. There seemed to be some fear that the revolution in standard, or rather the adoption of a standard in conformity with the evolution of the applications of gas, would lead the gas industry into some unforeseen difficulty with local authorities, on the score of the change in the fundamental terms of the statutory bargain.

Some time ago, it was suggested in these columns that there would be much less disinclination to make the change if some important local governing bodies would lead the way in creating a precedent. The Gaslight and Coke Company have both an illuminating power standard and a calorific power one. That is a condition they unwillingly shouldered for diplomatic reasons. The London County Council took the initiative in the matter; and the Council have admitted the error, or rather the needlessness, of the

dual standard by what they themselves did last year in the cases of the Wandsworth and the South Suburban Gas Companies. It was at the instance of the Council that, in both these largely extended Companies, calorific value supplanted illuminating power as the standard quality of gas; and there was little hesitation on the part of the Companies, when the conditions were settled, to accept what was proposed. In the initial work of making adjustment between the parliamentary standard of quality and modern conditions of use, it was an important thing to have the countenance and aid of an independent body of such high position as the London County Council, who were guided in this matter by the experts of their Chemical Department. Now, in the group of Bills reviewed this week, we have the Morley and the York Corporations—the one old gas suppliers, the other prospective gas suppliers—of their own volition asking that the standard of quality may be the calorific value of the gas. This movement on the part of these authorities will do much to disarm opposition and attempts to make conditional agreements in future cases in which gas companies are concerned. There is in the coming session only one gas company voluntarily applying for the change, and that is the Porthcawl Company. The remaining promoters—company and local authority—are continuing the illuminating power standard, using the "Metropolitan" No. 2 burner for testing. In two instances, an illuminating power standard of 12 candles is suggested, and in one 13 candles.

In all three cases in which a calorific standard is sought, the figures, technical nomenclature, and conditions (other than as to penalties in two of the cases) of the South Suburban clauses are followed. The nomenclature and the conditions attaching to the South Suburban standard, it was suggested in these columns on a former occasion, should be the model, on the ground that they were both simple and British. There is no reason, however, why there should be adherence to the figures. The standard must be subject to individual conditions; and the standard should be at a figure which there is every prospect of being able to maintain under the conditions of the nearest available coal supply and working circumstances. The parliamentary authorities, in the matter of illuminating power, have not only standardized the conditions of testing, but have also, in recent sessions, standardized the standard itself at 14 candles. In these days when heat and flame temperatures are the essentials, this figure does not do much harm, though it is no positive guarantee that the consumer gets what he really needs. In setting out in the adoption of calorific value, we hope the parliamentary authorities will not establish a standard figure from which there is no departure. It will be quite easy for every gas undertaking to test the coals (under the local conditions of working) that are commercially the best for their consumers and concern, and to ask Parliament for a standard accordingly, and a standard that—accident and emergency excepted—can be guaranteed, and which will contribute to, and not detract from, economical working. The guaranteed standard need not be the one to which an undertaking will work. The aim can always be at something higher, with an effort to a permissible uniformity. This has been recognized in the conditions laid down in the precedents; and the stipulation is an excellent one. In considering this matter, the parliamentary authorities should bear in mind that a high number of B.Th.U. per cubic foot of gas at a high price may be less economical for consumers than a lower number of B.Th.U. per cubic foot at a lower price.

There is little doubt that in the present session more will be heard of calorific value standards than is foreshadowed by the clauses in the Bills that start their parliamentary career with the view of adoption. Last session there were instances of the advisers of opposing local authorities recommending them to apply for the insertion of a calorific value standard. But Parliament was not then prepared for this; and, in such a matter, there ought not to be any chance figure placed, as a standard, upon any undertaking. The position now, however, is somewhat different. Parliament has before it the Wandsworth and South Suburban precedents; and these precedents will in all probability be used henceforth as levers. In view of this, let us betimes utter a word of caution. Gas promoters in the coming and subsequent sessions, ought not, where there is opposition, to go to Parliament without being fully satisfied on the point as to the calorific standard to which they can commercially and technically assent, so as to be, if the question is raised, in a position to argue the matter, and, if necessary, effect an agreement. The precedents, too, should be studied.

Local Authority Gas Measures.

In the preceding article, allusion is made to the important move on the part of two corporations for setting up a calorific value standard in place of the illuminating power one. Other matters of interest affecting gas supply are brought, by the local authority measures for next session, within the range of parliamentary endorsement. Four authorities are projecting the taking-over of the rights and privileges of gas supply in the areas under their government. In all four cases, the applications are made in pursuance of purchase clauses inserted in the Acts of other local authorities or of companies. In the cases of Windermere and York, purchase clauses were included in the Companies' Acts of last year; while in the cases of the Brumby and Frodingham District Council and the Mynyddislwyn Council, the purchase proposals come within the terms of clauses which give a local authority power to acquire part of the gas-distribution system of any local authority supplying within the administrative territory of the former. In the case of the Brumby and Frodingham Council, a portion of their administrative area is supplied by the Scunthorpe District Council; and the Act under which the latter operate in the matter of gas supply embraces powers enabling the present promoters to apply for authority to purchase the section of the distribution system, without incurring opposition from the existing owners. The same in the case of the Mynyddislwyn Council. Under powers in the Risca and Bedwellty Gas Acts, they are proposing to acquire the portions of the two authorities' gas supply systems within their governmental area.

There is something to be said both for and against such dismemberment. We do not like the idea of one local authority making profits out of the district of another local authority. On the other hand, if the existing gas undertakings are efficiently and fully supplying the areas concerned in such applications, there clearly ought to be greater advantage to consumers in their continuing to do so than in the setting up of another small concern for the special purpose. The economic reasons form the best side of the cases for consolidation which Parliament have been confirming in past, and will do again in the present and future, sessions. But here are cases in which the antithesis to consolidation is proposed. Therefore, better in our opinion than dismemberment would be joint control of a single undertaking, or provision for all the surplus profits to be utilized for the benefit of the concern and of the consumers at large, and not be applied in aid of the rates of the district of the works' owning authority—always providing that the outer area was efficiently served, and that it was not in any way at the expense of the consumers living in the inner area.

This brings us to a point that has been previously discussed in these columns in connection with new gas promotions. There has been on the part of Parliament a leaning to a greater regulation of the finances of municipal trading concerns, by, in one way, a direction that surplus profits shall be utilized for improving and cheapening the service, instead of unlimited profits being made out of the consumers of the commodity, and applied to the general rates. In all cases of purchase, Parliament has a good opportunity for regulating these matters in accordance with the true fundamental reason (such as it is) for municipal management of a trading concern. But Parliament shows a lamentable irregularity of practice in this regard. The District Council of Brumby and Frodingham are to be commended for setting a good example in the coming session. There are excellent spirit and good policy on their part in coming forward with financial proposals which provide for balances of revenue (after making all legitimate charges upon it) being applied to the reduction of the price of gas, or, if unfortunately there has been a prior deficiency, and recourse has been had to the district fund for a temporary loan to meet it, to the satisfaction of the latter by repayment. None of the other authorities are proposing similar dealings with the revenue balances.

They all, however, have their eyes on the district fund; and, as a matter of fact, it is probable that, if Parliament compelled in those cases what the Brumby authorities are voluntarily adopting, the greater part of the charm of gas-works ownership would in the view of the other authorities disappear. Parliament realizes that freedom in this matter has led to abuse. Parliament has the opportunity of placing regulation upon the municipal bodies now seeking to buy

the local gas undertakings, and of preventing in their cases any growth of the abuse in the future. The present members of the local bodies cannot pledge their successors to any right action without express enactment. The components of the existing bodies have an insecure tenure of representative office in the local government. The *personnel* is constantly shifting and changing; and it is therefore more for the future than the present that regulation is needed. Indeed, history shows us that the appetite grows for rate relief by the aid of profits from municipal trading undertakings. Parliament is in existence to legislate—and to legislate so that justice may blot out injustice. While one section of ratepayers bears the burden of local expenditure in greater proportion than another, there is an injustice to be remedied; and to-day the gas-consuming ratepayers in many places are bearing a disproportionate part of the local expenditure.

Among miscellaneous matters in the measures reviewed this week, there is reminder of the stiff fight that took place last year over the standard price of the York Gas Company, when it was fixed at the absurdly low figure of 2s. 3d., and the Corporation would preferably have had it put lower still. The Corporation are now proposing to take over the gas supply; and we see they have placed in the Bill the proposal that the price of gas shall not exceed 2s. 6d. per 1000 cubic feet. What reason could the Corporation advance against Parliament adopting, instead of 2s. 6d., the figure that they themselves contended last year was the correct one for the Company's standard price? We see that the Corporation have the good grace to suggest that it shall be enacted that, if the price of gas shall at any time exceed 2s. 3d. per 1000 cubic feet in the "inner" supply area, no part of the revenue balance for that year shall be transferred to the district fund, but shall be carried forward to the succeeding year, and be applied to the reduction of the price of gas. There are only two other general matters which here call for special reference. In the Brumby and Windermere Bills, the residuals restriction appears; and the promoters must see that the objectionable words are eliminated. To retain them in view of the report of the Joint Committee would be absurd, and in future might be embarrassing. Central suspension of lamps for street-lighting is gaining favour with local authorities; and the desire is spreading to obtain statutory right, subject to compensation and other conditions, to the attachment to premises of brackets, wires, pipes, and other appliances. The London County Council, in their General Powers Bill, are proposing to obtain the necessary authorization from all the Metropolitan Borough Councils, and the Leeds and West Bromwich Corporations have similar clauses in their Bills. There ought to be certain specific exemptions in such clauses—such as gas and electricity show-rooms and offices. Otherwise there may arise from the power some Gilbertian situations.

The Humphrey Pump.

When in 1909 Mr. H. A. Humphrey introduced to the engineering world his remarkably simple pump—a pump which depended not upon moving parts, but upon the conversion into pressure energy of the kinetic energy imparted to a column of water by the explosion of gas—the members of that world were inclined to regard it in sceptic mood. But they knew sufficient of Mr. Humphrey to be convinced that he was not putting his name to a thing, and his reputation to test, without being satisfied that there confronted him an ultimate success. There was something revolutionary about the whole thing; something so beautifully simple that, for the time, one could not bring himself to accept the notion of a pump moving large volumes of water or other liquids without the use of an engine external to the pump itself. But here was the scheme for, at one sweep, shifting the power-providing force from the cylinder of an engine to the inside of the pump itself—dispensing with slide-pistons, fly-wheels, connecting-rods, crank-shaft, bearings, glands, in fact all moving parts save simple valves and interlocking gear—and causing the force exerted by explosion to act on a column of water or other fluid. Simplicity of this kind means a large suppression of friction, wear and tear, and labour troubles. The pump has since made history, and has added to our dynamic and kinetic knowledge. The doubting stage soon passed. Men of such enterprise as the Chief Engineer of the Metropolitan Water Board (Mr. W. B. Bryan, M.Inst.C.E.) and other engineers of eminence felt that the bold simplicity of the invention, and the promise that experimental trials presented, urged for it actual working trial.

Progress

We know what has happened since 1909. A paper that Mr. H. de P. Birkett read on the subject before the London and Southern Junior Gas Association last Friday concluded with the words: "I am glad to be able to say that the number of pumps now installed or under construction for commercial purposes ensures the establishment of this invention as not only a powerful factor in the pumping world, but also as a further nail in the coffin of steam, and a justification of those who have pinned their faith to gas power." The economies and high mechanical efficiencies of the pump have been proved; and steam for the moving of large bodies of water or other liquids stands in greater danger than ever. The pump is at work in various places to-day, for sewage lifting, irrigation, and water-works purposes. The installation in which we shall be most interested is that at the Chingford works of the Metropolitan Water Board, where Mr. Bryan has installed five pumps—four of a daily capacity of 40 million gallons, and one of a capacity of 20 million gallons (with a lift of 25 to 30 feet), or a total of 180 million gallons a day. Larger pumps than these have been constructed; one, for example, for the Egyptian Government, having a capacity of about 100 million gallons per day.

And Congratulation.

Look on this position, and then on the position existing in 1909—only three years ago. We know the difficulty of revolutionizing people's ideas; but with such a revolutionary dynamic proposal as this one, there is every cause to congratulate the inventor upon the quick establishment of a high status for the pump in the realm of power. Mr. Birkett's paper tells us again of the principles underlying the construction and working of the pump; he tells us, too, of the improvements in detail that have been effected since the pump was introduced. Having carefully read the account of these improvements, it is a compliment to the inventor to say that we are astonished that Mr. Birkett has so little upon which to inform the world that is really new about the pump. Mr. Birkett will understand that this is said without any disparagement of his interesting contribution. We can well understand that in the initial work of construction in dealing with liquids of varying density, &c., that the calculations of structural parts and energy required in relation to the work to be accomplished have been heavy and intricate. But every successful achievement lightens the ground work, and contributes to the assurance as to the future maintenance and enlargement of the place the pump has so quickly taken in the work of the world.

A National Asset.

From the returns just published by the Board of Trade, it is seen that the total known coal production of the world during the year 1911 was about 1050 million tons, compared with some 1035 million tons for the preceding year. These figures are exclusive of brown coal and lignite. Of the huge total named for 1911, the United Kingdom produced more than one-fourth, and the United States more than two-fifths. Though in the aggregate the output of the United States was thus very much larger than that of this country (being nearly 63 per cent. more) the production of coal in the United Kingdom, as compared with the population, still surpasses that of the United States—the figures respectively being 6 tons per head, and under 5 tons. The output of this country in 1911 exceeded that of any other year; but that of the United States was somewhat less than in the preceding twelve months. The records show a larger export from the United Kingdom than the aggregate of the exports from the other countries included in the returns; the annual averages for the years 1906-10 being 83½ million tons from this country, and 63½ million tons from the other countries. The latter figures, however, exclude the quantities exported from certain countries for the use of steamers engaged in foreign trade. In the matter of consumption of coal per head in 1911, the figure for the United Kingdom is 4·08 tons. The quantity of coal consumed in the production of pig iron was nearly 19¼ million tons, and that used for locomotive purposes over 12¾ million tons. The latest returns included for gas undertakings relate to 1910 (or March, 1911, for local authorities); and these show that in that year there were carbonized 15,397,783 tons.

A Big Scheme.

There have been vague rumours and equally vague newspaper references to an extensive scheme of building right in the heart of Theatreland, for exhibition and entertainment purposes. The ideas of the promoters are represented to be spacious in character, and oriental in their brilliance. For such a scheme land is naturally required; and, looking round, the project has been connected up with a private measure in Parliament, intituled "Arundell Estate (closing of Arundell Street and Panton Square)." The extensive piece of land that is represented by this simple title, and which lies between Coventry Street and Shaftesbury Avenue, would make an ideal site—a better could not be found in the world—for a big enterprise of the kind. But the closing of streets involves all sorts of things; among others, a rearrangement of the gas, electricity, and water distribution systems in those quarters. The owners, however, in the Bill in question propose that power shall be conferred upon them to remove any main, pipe, tube, wire, or apparatus laid down or placed therein or thereover for supplying water, gas, or electricity . . . causing as little detriment and inconvenience as circumstances admit, and making reasonable compensation to any company or person for any damage caused by any operations of the owners under the powers of the section. We rather think that the Gaslight and Coke Company and the other companies concerned will see that the clause is modified so that the power of execution only rests with them. There is no confirmation or denial of the exhibition or entertainment project so far as this particular site is concerned. But another aspect of the matter that has been put forward is that the intention of the promoters of the Bill is purely to obtain powers in order that, when the existing leases of premises upon the site of the street and square fall in, they may be in a position to build on the whole site.

Provisional Order Obstacles.

The report of the Board of Trade on the Gas and Water Provisional Orders which received their attention last year is published practically *in extenso* in other columns. There were fifteen Gas Orders under consideration; and they were all ratified by the Board, and with little change. We are glad to see that the promoters of such Orders are carefully guarded by the Board against local authorities who withhold consent, or who offer opposition. The Board are fully aware of the foibles and autocratic moods of Little Peddlington Councils; and therefore they take good care there is thorough investigation of the reasons laid before them for not giving consent and for opposition. A special inquiry was held at Tipperary, and the Order succeeded. In a case in which it was submitted that a colliery company are likely to break earth and commence operations, and will probably be in a position to supply gas some years hence, the Board did not consider this a reasonable or sufficient cause to deny powers to the concern that has been meeting for some time past the gas needs of the district. In a third case, objection was taken to a site proposed for gas-works, and an alternative one was suggested. The Board sent a representative to examine the two sites; and the promoters' own site succeeded on the ground of greater fitness, though a screen of trees is to protect the eyes of occupants of neighbouring property from offending structure. It is satisfactory that so much care is exercised in such matters. But there is another side to these Provisional Orders. We recognize some of them as being those of companies who had to meet, subsequent to success with the Board of Trade, opposition in both Houses of Parliament; and that is where what was intended to be a less expensive mode of securing powers than by going to Parliament direct actually, in some cases, becomes an expensive procedure. In the cases of the Swansea and West Kent Orders, for instance, the chemical manufacturers were allowed to work up heavy bills of costs for the promoters to gain something to which a Joint Committee of the two Houses of Parliament have said the chemical people are not entitled.

Trading Profits and the Rates.

No one will be inclined to accuse the Manchester City Council of having taken insufficient time to arrive at a sound decision with regard to the recommendations of the Trading Profits Special Committee appointed in 1911 to consider and report as to the basis upon which each Trading Committee of the Corporation should make contributions in aid of the city rate. As the result of their investigations, the Committee recommended that for a period of three years the Gas Committee should contribute in aid of the city rate 1¾ per cent. on the capital expended; the Electricity Committee, 1 per cent.; the Tramways Committee, 5 per cent.; and the Markets Committee, 2 per cent. Last week's discussion was the third which has taken place in the Council; and it brought the matter to a conclusion. The recommendations of the Committee were adopted so far as the amounts of contributions were concerned; but an amendment was carried that the scheme should only remain in force for twelve months, instead of three years, as recommended by the Committee. The principle of subsidizing the rates by means of profits taken from municipal trading concerns, is one that appears to be enjoying a diminishing amount of favour as time goes on. Possibly this is owing to it becoming more and more widely recognized that such a practice, if engaged in to any serious extent, may have disadvantageous results in addition to the placing upon the customers of the undertakings concerned of burdens which would otherwise have to be borne by the ratepayers generally. For instance, a general use of gas in place of coal would be an incalculable gain to the community, by its beneficial effects on the purity of the atmosphere; and this is an end which can only be secured by selling gas at the lowest possible figure. An efficient service at the cheapest practicable charge is a good object for municipalities to aim at, and a policy which we shall be glad to see universally adopted. If, however, there must be a contribution in aid of the rates, some fixed percentage such as has now been adopted as an experiment in Manchester, would seem to be a desirable method of procedure.

Competition of American Coal.

This question is giving more worry to our Welsh colliery owners than they care to confess. Coal from the United States is competing with the Welsh variety in various parts of the world; and as recent publication has shown, even on the Mediterranean shores, and to a larger extent still in South America. The Welsh owners are looking closer into the question of why it is that American coal so much farther inland than Welsh coal can be supplied at the sea board at a much cheaper rate per ton. The answer will probably be partly found in the larger use of coal-cutting machinery and in a greater output per man. Freightage is the drawback of American coal; but yet in the American markets, owners are beginning to boast that they could deliver coal at British ports cheaper than coal producers of this country are doing. We have not yet seen the evidence of this; some of the larger coal consumers who are not altogether satisfied with our own colliery proprietors' actions would like to see the boast materialize, in order that competition might bring its reducing power to bear upon home prices when they get somewhat obese.

Lewes on Liquid Fuel.

A further source of competition with coal and coke is liquid fuel; and, though the demand for coal is not descending but contrariwise, it follows that to the extent that liquid fuel is used it displaces solid fuel. But as Professor Vivian B. Lewes says in the first of his Cantor Lectures on this subject, the primary essential to liquid fuel becoming a competitor with solid fuel is that the former must be sufficiently plentiful to enable it to compete in the matters of both distribution and price. We have yet to see whether the present Cantor Lectures produce anything that can claim direct interest for the gas industry, as there is little prospect of the lines of utility bringing liquid fuel into conflict with gas save in connection with internal combustion engines. In his first lecture, Professor Lewes treated of the theories as to the formation of petroleum that have been presented to the knowledge-loving world. But he dismisses all save the one that the source from which the main bulk of oil has been derived is marine vegetation. Though some investigators of this problem of petroleum origin are opposed to the theory accepted by the Professor, he thinks it fits in better with the observed facts than any other. The world's petroleum output, he shows, now reaches enormous figures, and its sources appear to be well distributed, which facts make its position in the markets the more secure, so long as the laws of supply and demand, and not trusts, rule it commercially. There was reference in the lecture to the tests of last century in carbonizing seaweed at low red heats, and to the gas and oil-tar results. We are not expecting to hear of the financial results of any littorally situated gas-works being improved by taking advantage of a free supply of seaweed.

PERSONAL.

It was mentioned in the "JOURNAL" a fortnight ago that Mr. J. FERGUSON BELL, the Engineer and Manager of the Derby Gas Company, was a candidate for a seat on the Municipal Council. He was cordially supported by the Conservatives, whose interests he was to represent, and was elected by 568 votes against 463—a majority of 105.

The successful candidate for the post of Gas Manager at Stewarton, as successor to Mr. M. D. Campbell, who has recently been appointed to Fraserburgh, is Mr. A. STEWART, the Manager of the Whitburn Gas-Works in West Lothian, where he has been for three years. Mr. Stewart began his career in the gas profession under his father, the late Mr. Thomas Stewart, who managed the Larkhall Gas-Works for 25 years. He then spent over ten years in the Hamilton Gas-Works previous to obtaining the post at Whitburn, where he is being succeeded by his brother THOMAS STEWART, who has been for the last seven years at Lanark, under his brother John as Manager. It is interesting to note that at the present time five brothers of this family are all holding positions as gas managers, and all were born in the house at the Larkhall Gas-Works.

Alderman JAMES CRAIG, the Chairman of the Gas Committee of the Belfast Corporation, has been appointed to the Commission of the Peace for the city. Mr. Craig, who has been a member of the City Council since 1903, was elected Chairman of the Gas Committee in 1910. He has taken a very prominent part in the affairs of the Committee; and it was mainly through his efforts that the present system of discount on gas accounts was adopted—a system which has resulted in a saving to the ratepayers of £34,000 per annum. In the controversy which for years raged round the site of the gas-works extensions in Belfast, Mr. Craig was one of the principal opponents of the proposal to erect auxiliary gas-works at the Twin Islands. He was a supporter of the scheme of vertical retorts which was opened last week (as reported elsewhere), when, with the other members of the Committee, he entertained a large party of experts to luncheon. Mr. Craig is 62 years of age, and is in the grain business. A like honour has been conferred upon Mr. JAMES HOLLYWOOD, the Chairman of the Belfast and District Water Commissioners.

OBITUARY.

ROBERT DEMPSTER, SENIOR.

IN the last number of the "JOURNAL," it was briefly recorded that Mr. Robert Dempster, sen., of Eden Hall, Penmaenmawr, died early on the previous Sunday. He was in his eighty-fifth year, and had been for some little time so seriously ill that no hopes were entertained of his recovery.

Robert Dempster was born at Cupar, Fife, on Oct. 17, 1828. After serving his time as apprentice to Provost Honeyman, he went to Edinburgh, at the age of fifteen, to learn the business of meter manufacturing at the works of Messrs. Cochrane and Co. During the few years spent in Edinburgh, he obtained a thorough knowledge of the business in which he was engaged, and qualified himself for the post of meter inspector at the Dundee Gas-Works. At Dundee he married Elizabeth Bonella, of Springfield, who was a congenial companion and loving wife during fifty-five years of happy married life.

From Dundee, Mr. Dempster moved to the Phœnix Gas-Works, London, where he was appointed foreman in the meter-repairing department. He was compelled, however, after some years, to resign, as he found his health suffered severely from the fumes of the then unpurified gas. This was an important crisis in his life. With a wife and young family dependent upon him, he found himself compelled to leave the trade for which he had been trained, and to fit himself for a new sphere. With characteristic energy, he set himself to learn drawing at a night class, and gained a knowledge of gas plant and retort building. He then applied for the post of Gas Manager and Engineer at the Elland Gas-Works, and was appointed mainly on the strength of the merit of a drawing of a retort-bench and fittings which he had made in his leisure time. Under Mr. Dempster's management the works at Elland were most successful, and the working was greatly improved. As a result of his success at the gas-works, he earned a local reputation as an expert on gas production, and became in course of time Consulting Engineer to many large mills in the neighbourhood of Elland having gas plants of their own. This consulting work led in a short time to Mr. Dempster undertaking retort-building contracts, which he had at first sublet, and later executed in his own works.

From the time of the founding of the now world-renowned firm of Robert Dempster and Sons till 1880, when Mr. Dempster retired, the business grew with remarkable rapidity. After his retirement from the management of the firm he had founded, Mr. Dempster continued to act as a Consulting Gas Engineer, and appeared as an expert parliamentary witness in several important arbitrations. In the Dewsbury and Batley case, he appeared for the Dewsbury Corporation; and he was the Engineer for the Tyldesley Gas-Works. He also gave evidence on the Mirfield and other Gas Bills. In the later years of his life, he bought or constructed small gas-works at Penmaenmawr, Sedbergh (Yorks.), and Langport.

He travelled in Egypt and Palestine, and wrote an interesting account of his journey. The last twenty-five years of his life were spent in semi-retirement at his charming home in Penmaenmawr. His mind remained fresh and vigorous to within a short time of his death. He preserved a keen interest in all branches of science, and kept himself informed of the latest ideas in the scientific world. He was an associate member of the Institution of Civil Engineers, and a prominent Freemason; being attached to the St. Trills (Colwyn Bay) Lodge. In politics, he was a very staunch Conservative.

By his numerous friends Mr. Dempster will be remembered for his fund of anecdote, his geniality, warm-heartedness, and unfailing kindness. His interest in, and sympathy with, young men and new ideas was most remarkable in a man of his years, and will long be remembered with gratitude by those who were privileged to know him as a friend.

The funeral took place last Wednesday. At the English Congregational Church, where the deceased was Senior Deacon, a service was conducted by the Rev. J. Reece Evans, the Pastor. The principal mourners were the members of the family, by whom, as well as by personal friends and others, beautiful floral tributes were sent. Mr. Dempster leaves four sons and three daughters.

In the report of the Directors of the Colne Valley Water Company which has just been issued, they record with deep regret the death of their able and much-valued colleague Mr. JOHN ROBERT HOLLOND, who was associated with the Company from its inception, and with the Board for a continuous period of nearly forty years. In April, 1879, he was appointed Chairman in succession to Lord Malden, the first Chairman of the Company, and held office until March, 1904—a period of twenty-five years.

South Metropolitan Gas Company's Dividend.

We learn from the Secretary of the South Metropolitan Gas Company (Mr. F. M'Leod) that the accounts for the half year ended the 31st of December show that (subject to audit) the balance to the credit of the net revenue account will enable the Directors to recommend the payment of the full statutory dividend at the rate of £5 9s. 4d. per cent. per annum, reducing by £31,727 the amount carried forward last June.

Vertical Retorts for Liverpool.

The Directors of the Liverpool United Gas Company, on the recommendation of their Engineer, Mr. Edward Allen, M.Inst.C.E., have decided to adopt vertical retorts, and have placed a contract with West's Gas Improvement Company, Limited, for a complete installation on the Glover-West system, capable of producing approximately 2½ million cubic feet of gas per day. The installation is to be placed in No. 1 retort-house at the Linacre station—half of which is to be reconstructed to suit the vertical retorts.

Masonic.—Mr. J. A. Chisholm (Messrs. James Russell and Sons, Limited, of Wednesbury) has been appointed Provincial Grand Sword-Bearer in the Provincial Grand Mark Lodge of Nottinghamshire.

Professor Lewes on "Liquid Fuel."—At the Royal Society of Arts last night, Professor Vivian B. Lewes, F.I.C., F.C.S., delivered the second of a series of three Cantor Lectures on the above-named subject. [A report of the first lecture, given on Monday evening last week, will be found elsewhere.] He dealt with the burning of liquid fuel for the production of power, the arrangements necessary for the consumption of this fuel, the direct combustion of oil in engines, surface combustion, and its influence on the future use of liquid fuel. The concluding lecture will be given next Monday.

The Cheltenham Coal-Liming Process.—In the review of engineering progress in the past year contained in the Engineering Supplement to "The Times" last Wednesday, the following reference is made to the coal-lining process; "The revival of the idea of liming the coal before carbonization, which has been carried out for the past three years at the Cheltenham Gas-Works, is one that may develop into great importance. When this process was introduced by Cooper in 1882, it was with the idea of increasing the yield of ammonia from the coal; but as modified at Cheltenham, where 2 per cent. of lime is thoroughly mixed with the coal as it passes from the crushers, and is made to adhere to the surface of the small coal by a steam-jet, it has been found to increase the yield both of ammonia and of gas, to lessen the number of stopped pipes, and to reduce the sulphur compounds in the gas to a very large extent, without any serious injury to the coke. . . . If the process continues to show the same results as it has been doing, many companies will be willing to adopt it, not only for the slight increase in gas and ammonium sulphate made per ton, but also because they would get nearly the same purifying effect as in the old days of lime purification, and at the same time would not have to deal with the nuisance created by the residual material."

GAS BILLS FOR 1913.

[Fourth Article.]

We now come to the measures promoted by local authorities. The bulk of these are Omnibus Bills, in which gas has more or less a minor part; but in others gas supply is the chief or only feature.

In a General Powers Bill, the District Council of Barry have included a batch of clauses common in modern gas legislation. In the first place, they ask for the repeal of a number of provisions in the Barry and Cadoxton Gas and Water Acts, 1886 and 1889, save clauses specified in one of the schedules to the present measure, in respect of which the Council "shall have the powers and rights, and be subject to the obligations, of such provisions as if the Council were named therein, instead of the Barry and Cadoxton Gas and Water Company." The limits of supply are extended to certain small parishes. Lands are scheduled and works powers are taken. Most of the other clauses are of ordinary form. It is proposed that the price of gas shall not at any time exceed 3s. 6d. per 1000 cubic feet; and the standard illuminating power is placed at 12 candles. A stand-by clause referring to both gas and electricity is included. In addition to the usual provision as to the employment of anti-fluctuators for gas-engines, the Council take power to compel every user of a stationary internal combustion engine, whether supplied by town or any other gas, to provide and employ an effective silencer on the exhaust. Any person neglecting to carry out the provisions of this section is to be liable to a penalty not exceeding £10, and to a daily penalty not exceeding 40s. Power is also taken to increase the maximum amount of the reserve fund from £5000 to £10,000. [*Parliamentary Agents: Messrs. Torr and Co.*]

The Brumby and Frodingham District Council are promoting a Bill to provide for the transfer to them of so much of the gas-works and plant of the District Council of Scunthorpe as is situate within the district of the promoters. In 1899, the Scunthorpe Council were authorized to supply gas throughout their district and the area then served with gas by the Frodingham Iron and Steel Company. The Company supplied gas to the Station Hotel and to the Great Central Railway Company for lighting the Frodingham station, and certain houses in Frodingham Road; the Scunthorpe Council are now supplying the hotel and station and certain houses in and near Frodingham Road outside their limits of supply. By the Scunthorpe Act of 1899, power was given to any local authority in whose district the Council were supplying gas, to give six months' notice of their desire to purchase such parts of the works as were within their districts, and to apply to Parliament or to the Local Government Board for power to purchase without opposition (except as to details) from Scunthorpe. With the exception of the premises already referred to, the whole of the district of the promoting Council is without a supply of gas; and the Council therefore desire the purchasing powers and authorization to undertake the supply of their territory, including at the same time the parish of Ashby. The estimates for the purchase of land and the erection of works amount to £20,000. Turning to the clauses, it is proposed that purchase shall be by agreement, or, failing that, at a price to be determined by an engineer appointed by the Local Government Board. The succeeding clauses make provision for dissolving the powers of the Scunthorpe Council in the area, and for all that is necessary in connection with the transfer. Provision is likewise made for the supply of gas in bulk by the Scunthorpe Council to the Brumby Council, pending the construction of gas-works, for the use of the premises in the area at present consuming gas. The residuals restriction is included in the works clause; but the promoters will no doubt see that this is removed, in view of the report of the recent Joint Committee. It is proposed that the price charged for gas shall not at any time exceed 4s. per 1000 cubic feet. The standard illuminating power is placed at 14 candles, tested by modern means. The financial provisions contemplate the borrowing of such sum of money as may be necessary for the purchase of the portion within the promoters' area of the gas plant of the Scunthorpe Council, £20,000 for the purchase of land and the erection of gas-works, £1000 working capital, and such sums as the Local Government Board may sanction for the extension and improvement of the works, or other purposes relating to the business. The periods of repayment suggested are thirty years for the purchase money, forty years for the loan required for land and works, ten years for the working capital, and such period not exceeding sixty years as the Local Government Board may sanction for further loans. In connection with the clause referring to the application of revenue, there is a change which we much appreciate. The first four provisions of the clause are of the usual form—alluding (1) to payment of the working and establishment expenses and cost of maintenance of the undertaking; (2) to the payment of interest; (3) to the provision of the requisite appropriations, instalments, or sinking-fund payments in respect of moneys borrowed; and (4) to the use of revenue for the extension, improvement, and construction of works. The fifth provision is a change. It provides for the repayment to the district fund of any sum which the Council may at any time have provided out of the fund for the purpose of making good any deficiency in the revenue of the undertaking. The sixth provision is the old fifth one, referring to the reserve fund; and it winds up with (instead of permission to transfer balances to the district fund) these words: "And so much of any balance remaining in any year of the income of the gas-works undertaking (including the interest on the reserve fund when such fund amounts to one-fifth of the said aggregate capital expenditure) as may, in the opinion of the Council, not be required for carrying on, improving, or extending the gas-works undertaking, and paying the current expenses connected therewith *shall be applicable to the reduction of the price of gas* supplied by the Council. [*Parliamentary Agents: Messrs. Lees and Co.*]

In a Bill promoted by the Coventry Corporation, there appears a proposal to extend the limits within which the Corporation may supply gas, to the parishes of Binley, Keresley, Stoneleigh, Walsgrave-on-Sowe, Willenhall, and Wyken, all in Warwickshire. [*Parliamentary Agents: Messrs. Sharpe, Pritchard, and Co.*]

In a Bill promoted by the Leeds Corporation, they take power to attach to any building, with the consent of the owner, such brackets, lamps, wires, and attachments as may be required for lighting any street in the city. Where, in the opinion of the Corporation, consent is unreasonably refused, the Corporation propose an appeal to a petty sessional court, "who shall have power, having regard to the character of the building, and to the other circumstances of the case, to allow the attachment, subject to such terms as to compensation, or rent, or otherwise as they may think reasonable, or to disallow the same, and may determine by which of the parties the costs of the appeal are to be paid." There are other conditions for the protection of future owners, and for the temporary removal of attachments where necessary during reconstruction or repair of the building. [*Parliamentary Agents: Messrs. Sharpe, Pritchard, and Co.*]

In an Omnibus Bill, the Leicester Corporation take power to increase the gas reserve fund to an amount not exceeding £150,000. [*Parliamentary Agents: Messrs. Dyson and Co.*]

The Liverpool Corporation have included, in the miscellaneous section of a Bill they have in Parliament, a clause by which they seek to secure satisfaction for damage to lamps by the drivers of vehicles. The clause reads: "If any driver of any vehicle shall carelessly or accidentally break any lamp, lamp iron, or lamp post, or the furniture thereof, or extinguish the light of any such lamp, and shall not upon demand make satisfaction for the damage or injury so done, it shall be lawful for any justice to summon the party complained of, and the employer of any such driver, and for any justice to examine the matter of the complaint, and award such sum of money by way of satisfaction for such damage as such justice shall think reasonable." [*Parliamentary Agents: Messrs. Sherwood and Co.*]

The London County Council are, in their General Powers Bill, proposing a very broad power for the whole of the Metropolitan Borough Councils in regard to the attachment of brackets, &c., to buildings for public lighting. The clause runs: "The Council of any Metropolitan Borough may affix to the external wall of any building situate within that borough such brackets, wires, pipes, lamps, and apparatus as may be necessary or convenient for the lighting of any street in such borough. Provided that the Council of such borough shall make compensation to any person sustaining injury by the affixing of any such brackets, wires, pipes, lamps, and apparatus as aforesaid; the amount of such compensation to be determined, in default of agreement, by arbitration under the Arbitration Act, 1889." [*Parliamentary Agents: Messrs. Dyson and Co.*]

The principal part of the Bill lodged by the District Council of Lymm refers to the purchase of the undertaking of the Lymm Water Company. [This will be dealt with when reviewing the water measures]. There are a few powers relating to the gas undertaking of the Council. Among others, authority is desired to the supply of gas to the parish of Warburton, and to the raising of £20,000 for the extension and improvement of the gas-works. The remaining clauses are of the ordinary character in modern legislation, and bring up to date the gas authorization of the Council. A standard lighting power of 14 candles is proposed; and the testing conditions are to be modernized. A gas stand-by clause is also included; and we see again the old and unnecessary 10 and 15 per cent. discounts clause. For the £20,000 proposed to be borrowed in connection with the gas undertaking, a repayment period of forty years is requested. The application of revenue clauses are in the old form, providing for balances being carried to the district fund, and not, as in the Brumby Bill, reserved for reduction of price. [*Parliamentary Agents: Messrs. Butterworth and Co.*]

We come to the Bill of the Morley Corporation in which (as in the Bills of the Porthcawl Company and York Corporation) there appears a proposal for substituting for illuminating power calorific value as the standard quality of gas. The standard, the conditions of testing, and the penalties for default are all on the lines of the South Suburban calorific value clauses in their 1912 Act [*see* Oct. 15, p. 220]. Briefly, a calorific value of 540 B.Th.U. gross per cubic foot is proposed as the standard. If on any testing the calorific value is below 447 B.Th.U., a second testing is to be made on the same day, but at an interval of not less than one hour from the time of making the first testing; and the average of the two testings is to be deemed to be the calorific value of the gas on that day. If on any day the calorific value is less than 475 B.Th.U. to an extent not exceeding 28 B.Th.U., there is to be a testing of the calorific value on each of the two following days; and the average of the three testings so made is to represent the calorific value of the gas on such one day. Where the calorific value on any day is less than 475 B.Th.U.,

the Corporation are to be liable to the following penalties: Where the deficiency does not exceed 14 B.Th.U., £2; where it exceeds 14 B.Th.U., but does not amount to 28 B.Th.U., a sum not exceeding £5; and for each complete 28 B.Th.U. a sum not exceeding £10. In the financial section of the Bill, the Corporation propose powers to borrow, with the consent of the Local Government Board, such further money as may be necessary for the purposes of the gas, water, or electricity undertaking. [*Parliamentary Agents: Messrs. Baker and Sons.*]

Another Purchase Bill is that of the Mynyddislwyn District Council. They desire to be empowered to acquire the gas distributing plant, and to supply gas within the Sirhowy Valley portion of their district. By the Risca District Council Act of 1909, and the Bedwellty Act of 1912, the two authorities were given powers of supply over portions of the area the administration of which is vested in the Mynyddislwyn Council. In the Risca Act is a clause empowering the last-named authority to give, after the expiration of three years from the passing of the Act, two years' notice of their desire to purchase the portion of the concern within their area. This has now been done. In the Bedwellty Act of 1912, the Council were granted the right within the next two available sessions to promote a Bill to purchase the portion of the Bedwellty gas-works concern within their area. The portions of the district in which the Risca and Bedwellty Councils are respectively authorized to supply gas are together known as the Sirhowy Valley; and it is the opinion of the promoting Council that this district can be better served by them than by two independent concerns. Then there is the Abercarn Council Act of 1902, in which authority was given to that body to supply gas in, *inter alia*, the parish of Mynyddislwyn. The Abercarn Council have never availed themselves of the power; and the promoters of the present Bill desire that the unexercised powers shall be repealed. The estimate for the erection of gas-works and the extension of the gas undertaking is £23,750. In the provisions referring to the transfer of the portion of the Bedwellty undertaking (called the northern undertaking), it is provided that the consideration for the transfer shall be £2705, a sum equal to the actual expenditure (if any) made by the Bedwellty Council on the provision of new gas-mains and other works within the gas limits of the Mynyddislwyn Council between Aug. 7, 1912, and the date of transfer, together with interest at the rate of 4 per cent. per annum from the date of transfer to the date of payment of the sums. The consideration for the transfer of the portion of the Risca plant (called the southern undertaking) is to be a price fixed, in default of agreement, by arbitration under the provisions of the Lands Clauses Act, provided that the arbitrators or the umpire, as the case may be, shall make no allowance for prospective profit. Another provision intends to make it lawful for the purchasing Council to, at any time after March 25, 1914, commence proceedings for the settlement of the price to be paid to the Risca Council. Lands are scheduled for works; and in this connection authorization is asked to divert a footpath. Power is desired to acquire an easement over a railway siding, and for the affording of facilities by the London and North-Western Railway Company for traffic to and from the gas-works. Rights of way across certain lands are also desired. As to the supply of gas, it is proposed, in addition to the repeal of the powers in the district of supply of the Abercarn Council, to make it unlawful for the Rhymney and Aber Valleys Gas and Water Company, under section 87 of their Act of 1898, to supply gas in bulk or otherwise within the gas limits, without the consent in writing of the Mynyddislwyn Council, except under, and subject to, the provisions of section 59 of the Rhymny Act of 1908. The proposal as to the price of gas is that it shall not exceed 5s. per 1000 cubic feet; and the standard illuminating power of the gas is placed at 14 candles. A gas stand-by clause is included. The Council seek the right to supply power gas, under the usual conditions. Regarding finance, the Council ask for power to borrow the money requisite for the purchase of the northern and southern plant of the two supplying authorities, for £1150 for the purchase of land and easements, for £23,750 for the erection of gas-works and the extension of the undertaking, £1000 for use as working capital, and additional moneys with the consent of the Local Government Board. The periods suggested for repayment are forty years for the purchase money, sixty years for the land and easements loan, forty-five years for the works and extension loan, ten years for the working capital, and a period not exceeding sixty years for moneys borrowed with the consent of the Local Government Board. The application of revenue clause provides for the transfer of any balances to the district fund. [*Parliamentary Agents: Messrs. Rees and Freres.*]

The West Bromwich Corporation, in their General Powers Bill, have a section referring to gas and electricity. The gas clauses are mostly of the ordinary character, and are for the purpose of bringing the powers of the undertaking in line with modern legislation. The principal proposal is that the standard illuminating power shall be 13 candles, tested by the modern means. The Corporation also desire relief from penalties by reason of the presence in the gas of sulphur compounds other than sulphuretted hydrogen. There are three stand-by clauses in the section of the Bill. The first gives the right to a minimum charge where a gas supply is laid on to any premises for which the occupier has at the same time a supply of electricity either from the Corporation or from an installation other than that of the Corporation; the second one gives the right to a standing charge where any person has a supply of gas laid on, and has at the same time a supply from an installation other than that of the Corporation; and the third one protects the Electricity Department where a user of current has a private installation. Provision is also made for the supply to any consumer free of charge of flat-flame burners suitable for the consumption of gas of the illuminating power to be prescribed in the Bill. The same clause also intends to confer power to supply and fix free of charge gas cooking-stoves and gas-fires for any consumer of gas supplied by the Corporation. It is further proposed to take powers for the attachment to any building of such brackets, wires, &c., as may be required for the lighting of the streets. Authorization is asked to the collection of gas and electricity charges with the other rates. [*Parliamentary Agents: Messrs. R. W. Cooper and Sons.*]

The Windermere District Council are desirous of obtaining possession of the property of the Windermere District Gas and Water Company; a purchase clause, to operate in the coming session, having been included in the Company's Act of 1912. In the preamble of the Bill which is being promoted by the Council to authorize the purchase, it is stated that estimates have been prepared for the extension and improvement of the works; and they amount to £32,000. The transfer and other clauses relative thereto are in the usual form. A long clause defines the limits of supply. In the one referring to the continuing and maintaining of works, the "by them" residuals restriction appears; but it is hoped the promoters will have it deleted, in view of the report of the Joint Committee. The limit to the price of gas is placed at 5s. 6d.; and the illuminating power clause prescribes 14 candles. [The water clauses will be noticed when dealing with the water legislation.] In addition to the money required for the purchase, the Council ask for power to borrow £11,000 for the extension and improvement of the gas-works, £21,000 for the extension and improvement of the water-works, and additional loans by sanction of the Local Government Board. The periods proposed for repayment are fifty years for the gas purchase and works extension moneys, sixty years for the water purchase and works extension loans, and for moneys borrowed with the consent of the Local Government Board a period not exceeding sixty years, as may be determined by the Board. The application of revenue clause provides for the transfer of balances to the district fund. [*Parliamentary Agents: Messrs. Speechly, Mumford, and Craig.*]

As the result of the appearance of the York Gas Company in Parliament last year, and the agreed insertion of a purchase clause, the Corporation are forward with a Bill to empower the transfer. According to the preamble, in addition to the money required for the purchase of the undertaking, the Corporation estimate that they will require £99,000 for further works and mains and for other purposes. Right at the beginning of the Bill, there is interest. In the clause referring to the "Interpretation of Acts," it is provided that sections 28 to 34 of the Gas-Works Clauses Act, 1871, shall be read as if "calorific value" were substituted for "illuminating power." The clauses referring to the purchase next claim attention; and on reference to the first schedule, it is seen that, under the agreement, the Corporation are to pay the Company a sum equal to £102 10s. per cent. for the £370,000 of ordinary and the £50,000 of preference stock. The Directors are to receive £5000 in satisfaction of all claims by them for compensation for loss of office; the sum to be divided among them as they may privately agree. For officials, compensation is to be on the Treasury scale in respect of any loss of office or diminution of salary or income by reason of the transfer. In default of agreement, there is to be arbitration in accordance with the provisions of the Arbitration Act, 1889. But in fixing such compensation in the case of any official who has been less than ten years in the employment of the Company, the Arbitrator is to take into account any reasonable offer by the Corporation to continue him in their employment. "Officials" are defined as the Secretary and Manager, the Solicitor, the Auditors (including the Auditor appointed by the Recorder), the superintendent of the works, and the office staffs and the collectors. Land, works, and other clauses appear. It is also to be enacted that the Corporation shall, where necessary, renew from time to time the belt of quick-growing trees planted along the north-western side of the works' land to screen, as far as may be practicable, the works from view of the premises known as Dalguise House, Heworth Croft, and Stannerton. Protecting clauses are inserted in favour of the West Riding County Council and the North-Eastern Railway Company. The limits of supply are defined; but in the extended area, if, after the expiration of five years from the passing of the Act, the Corporation have not laid down mains for the purpose of affording a supply of gas in any of the parishes, and shall not extend the mains to those parishes within twelve months after written notice from the Council requiring them to do so, nothing in the present measure is to prevent other persons supplying, and the Corporation are not to oppose the application for powers of supply by such persons. Within a radius of two miles from the centre of Ouse Bridge in the city, and such parts of the city as for the time being may extend beyond that radius (which portions of the limits of supply are called the "inner area"), the price of gas is not to exceed 2s. 6d. per 1000 cubic feet. Within the remainder of the limits of supply, the price is not to exceed the price charged in the "inner area" by more than 6d. per 1000 cubic feet. The calorific power clauses are on the lines of the South Suburban Company's, as referred to in dealing with the Morley Corporation Bill. Concerning penalties, the Bill proposes that (the standard being 540 B.Th.U. gross), when the calorific value is less than 475 B.Th.U.

and the deficiency does not amount to 28 B.Th.U., the penalty is to be £2; and for each complete 28 B.Th.U., £5. A gas stand-by clause appears. As to finances, the Corporation propose 45 years as the period for repayment of the purchase money, and the same period for the £99,000 required for the extension of the works. The Corporation also ask for power to borrow further sums under the sanction of the Local Government Board. The application of revenue clause is in the old form, asking permission to carry balances to the district fund. There is, however, a provision that, if in any year ending on March 31, the price charged by the Corporation for gas supplied by them within the inner area shall have exceeded 2s. 3d. per 1000 cubic feet, no part of the revenue of the undertaking for that year shall be carried to the district fund, and any balance of such revenue shall be carried forward to the revenue account of the undertaking for the next succeeding year, and shall be applied to the reduction of the price of gas. [*Parliamentary Agents: Messrs. Sharpe, Pritchard, and Co.*]

THE QUALITY OF LONDON GAS

In the Year 1912.

ARTICLES appeared in the "JOURNAL" last year (Vol. CXVIII., p. 215; CXIX., p. 381 and CXX., p. 278) giving statements of the results of the official testings of the gas supplied by the three Metropolitan Gas Companies during the first three quarters of the year. A corresponding statement is given below for the fourth quarter of the year; and following it is our customary summary of the results for the whole year. The summary for the year 1911 appeared in the "JOURNAL," Vol. CXVII., pp. 351, 422, where references were given to the summaries for previous years. In all cases the figures refer to the results of the testings made in the nineteen testing places which are under the control of the London County Council.

FOURTH QUARTER OF 1912.

ILLUMINATING POWER.

Table I. gives the average results of the testings of illuminating power, made with both the standard argand (No. 2 "Metropolitan") burner and the prescribed flat-flame burner, on the gas supplied by each of the three Companies. The figures for the fourth quarters of the years 1910 and 1911 are also given for the sake of comparison. The average illuminating power of the gas distributed by the Gaslight and Coke Company last quarter is about one-third of a candle lower than in the corresponding

TABLE I.—*Averages of All the Testings of Illuminating Power for the Fourth Quarter of the Year* [*Candles*].

Company.	No. 2 "Metropolitan" Argand.			Flat-Flame.		
	1910.	1911.	1912.	1910.	1911.	1912.
Gaslight and Coke .	14·92	14·82	14·47	8·56	8·47	8·17
South Metropolitan.	15·72	15·69	15·52	9·91	9·81	9·44
Commercial . . .	14·81	14·65	14·88	8·78	8·43	8·36

quarter of 1911. There is a smaller falling off in the case of the South Metropolitan Gas Company; while the Commercial Gas Company show an increase. In one week of the past quarter, the last-named Company had a return, with the standard argand, below 14 candles—viz, 13·95 candles; and in one week also the South Metropolitan Gas Company had a low return—viz., 13·76 candles. There is, however, no liability to forfeiture in respect of returns which are not as much as half a candle below the standard of 14 candles.

In five weeks of the quarter the Gaslight and Coke Company had returns from half a candle but less than one candle below the standard, and in one week a return below 13 candles—viz., 12·74 candles. The latter figure, unless disproved or shown to be due to unavoidable cause or accident on appeal to the Chief Gas Examiner, forthwith renders the Company liable to incur a forfeiture. In respect of returns between 13 and 13½ candles, the Company will only be liable to penalty if, on taking the average of the results for the day and those for the preceding and following day, a figure not exceeding 13½ is obtained. It is impossible from the available information to say whether in any of the five cases of returns above 13, but not above 13½, candles the three days' average will not be above 13½ candles; but as the single day's deficiency was very slight in all except one week (in which a return of 13·10 candles was made), it is highly improbable that the Company will incur a forfeiture in respect of many, if any, of these five weeks' returns. In all the remaining weeks of the quarter, there was at least one return below 14 but above 13½ candles.

The minimum results obtained with the flat-flame burner during the quarter were: For the Gaslight and Coke Company, 6·13 candles; for the South Metropolitan Gas Company, 8·23 candles; and for the Commercial Gas Company, 7·33 candles.

CALORIFIC POWER.

Table II. gives the average and maximum and minimum results of the testings of calorific power made during the quarter, alongside the corresponding figures for the fourth quarters of 1910 and 1911. It will be seen that the average calorific power of the gas supplied by the Gaslight and Coke Company last quarter was about 1 calorie per cubic foot lower than in the twelve months previously, while there was no change in the case of the gas supplied by the South Metropolitan Gas Company. The minimum return for the former Company—viz., 113·6 calories net—is above the limit of 112½ calories, below which the net calorific power of the Company's gas cannot fall on the average of three days' testings without rendering the Company liable to incur a forfeiture. The other two Companies are under no such liability in respect of testings of calorific power. The Commercial Company in one week had a return of 112·2 candles—*i.e.*, below the limit to which the Gaslight and Coke Company are required to work.

TABLE II.—*Summary of Testings of Calorific Power (Gross and Net) for the Fourth Quarter of the Year* [*Calories per Cubic Foot*].

Company.	Average.			Maximum.			Minimum.		
	1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.
Gaslight and Coke—									
Gross	137·6	137·1	136·1	148·5	149·5	148·6	127·5	129·4	128·7
Net	122·6	122·3	121·2	132·0	132·9	132·8	112·9	115·4	113·6
South Metropolitan—									
Gross	146·1	144·2	144·3	156·3	156·4	163·4	135·0	134·9	133·2
Net	130·2	128·5	128·5	139·4	140·6	145·8	120·3	119·7	118·4
Commercial—									
Gross	140·0	137·1	136·2	152·9	151·3	151·4	127·5	127·9	126·3
Net	124·7	122·3	121·9	136·6	136·6	136·5	114·0	113·9	112·2

SULPHUR.

The average and maximum figures obtained in the testings for sulphur during the quarter are given in Table III. They show that, in comparison with the same quarter of 1911, there has been a slight increase in the proportion of sulphur contained in the gas supplied by all the Companies.

TABLE III.—*Summary of Testings of the Sulphur in London Gas for the Fourth Quarter of the Year* [*Grains per 100 Cubic Feet*].

Company.	Average.			Maximum.		
	1910.	1911.	1912.	1910.	1911.	1912.
Gaslight and Coke .	34·0	33·9	36·4	53·5	57·8	63·2
South Metropolitan	28·8	24·9	26·2	58·0	46·2	55·5
Commercial . . .	26·9	25·2	28·8	46 0	45·2	47·5

RESULTS FOR THE COMPLETE YEAR.

ILLUMINATING POWER.

The averages of all the testings of illuminating power for the last three years are given in Table IV. It will be seen that 1912 shows an average for the argand testings lower than in 1911 in the case of the Gaslight and Coke Company by 0·38 candle, and in that of the South Metropolitan Gas Company by 0·21 candle. The Commercial Gas Company, on the other hand, have an increase of 0·29 candle. In the early part of 1912, the results were affected by the shortage of gas coal caused by the miners' strike, and comparison with previous years' figures is not therefore informative as to the normal trend of changing conditions in the gas industry. The minimum results obtained in the testings of illuminating power in 1912 have been reported in previous articles for each quarter of the year; and it is unnecessary to refer to them again.

TABLE IV.—*Averages of All the Testings of Illuminating Power for the Whole Year* [*Candles*].

Company.	No. 2 "Metropolitan" Argand.			Flat-Flame.		
	1910.	1911.	1912.	1910.	1911.	1912.
Gaslight and Coke .	15·22	14·90	14·52	9·04	8·59	8·25
South Metropolitan	15·86	15·70	15·49	10·15	9·90	9·38
Commercial . . .	14·72	14·60	14·89	8·68	8·47	8·43

CALORIFIC POWER.

Table V. gives a summary of the results of the testings of calorific power during 1912 and the two preceding years. There has been a fall of 2·1 calories per cubic foot in the calorific power of the gas supplied by the Gaslight and Coke Company in 1912, as compared with 1911; of 1·2 calories in that of the South Metropolitan Gas Company's supply; and a smaller fall in the case of the Commercial Company's gas. The calorific results for the past year are, like those for illuminating power, affected by the conditions that arose from the strike of coal miners, and the comparison with previous years is vitiated. On this account, also, there is no object in referring again to the minimum returns of calorific power, which have been recorded for each quarter in previous articles.

It is, however, of interest to note the difference now obtaining

TABLE V.—*Summary of Testings of Calorific Power (Gross and Net) for the Whole Year [Calories per Cubic Foot].*

Company.	Average.			Maximum.			Minimum.		
	1910.	1911.	1912.	1910.	1911.	19 2.	1910.	1911.	1912.
Gaslight and Coke—									
Gross	138·0	137·5	135·3	154·8	153·4	148·6	126 6	127·8	123·7
Net	122·9	122·7	120·6	139·4	138·0	132·8	112·6	114·3	110·2
South Metropolitan—									
Gross	146·6	144·6	143·4	158·0	160·3	163·4	135·0	133·5	131·7
Net	131·1	128·9	127·7	140·9	144·5	145·8	120·1	119·0	116·6
Commercial—									
Gross	138·4	137·1	136·2	159·4	152·2	151·4	118·3	123·6	122·0
Net	123·4	122·4	122·0	143·0	135·8	136·5	106·1	110·0	112·0

between the quality of the mixed gas supplies of the Gaslight and Coke and Commercial Gas Companies and the neat coal gas supply of the South Metropolitan Company. The latter is, on the average, approximately higher in illuminating power by one candle, and in calorific power by seven calories per cubic foot. Curiously enough, however, the fluctuations in calorific power appear to be somewhat greater with the coal gas supply than with the mixed gas; for there is a difference of about 30 calories between the maximum and minimum returns for the South Metropolitan Company and of less than 25 calories between those for the Gaslight and Coke Company.

PURITY.

The gas supplied by each of the three Companies was found to be free from sulphuretted hydrogen throughout the year. The results of the testings for sulphur in other forms are summarized in Table VI., from which it will be seen that while the proportion of sulphur in the gas of the South Metropolitan Gas Company has

TABLE VI.—*Summary of Testings of the Sulphur in London Gas for the Whole Year [Grains per 100 Cubic Feet].*

Company.	Average.			Maximum.		
	1910.	1911.	1912.	1910.	1911.	1912.
Gaslight and Coke .	35·3	34·0	34·8	71·9	62·9	63·2
South Metropolitan.	32·0	26·9	24·5	70·7	57·9	55·5
Commercial . . .	28·0	28·8	27·5	52·7	61·7	47·5

been reduced in two years from an average of 32 grains to 24·5 grains per 100 cubic feet, there has been little change in the proportion of sulphur in the gas supplied by the other two Companies. Such change as there has been, however, is in the direction of reduction.

PRESSURE.

The results of the testings of pressure during the past year are summarized in Table VII. It appears that the gas examiners no longer give the actual pressure-readings in the district of the Gaslight and Coke Company when they are higher than 40-10ths—perhaps because the gauges used are not adapted for measuring

TABLE VII.—*Maximum and Minimum Results of the Testings of Pressure in 1912 [Tenths of an Inch].*

Company.	No. of Testings in the Year.	Highest Pressure Observed.	Lowest Pressure Observed.
Gaslight and Coke	23	Over 40	34
South Metropolitan	6	45	34
Commercial	2	38	38

pressures in excess of this figure. The records show that in 31 observations in the districts of the three Companies the lowest reading was 34-10ths, which indicates that, given service-pipes and fittings of adequate size, no consumer should have experienced any difficulty in getting a sufficient pressure of gas for the efficient action of lighting and heating burners.

Fog and Street-Traffic Dangers.

The value of automatic street lighting by pressure wave was fully demonstrated last Wednesday in the Wood Green district. A very dense fog settled in this part of North London about 3 p.m.; and the Surveyor in charge of the district (Mr. C. H. Croxford) asked the Tottenham and Edmonton Gas Company, who supply the gas, whether the street-lamps might be lighted, in order to minimize as far as possible the danger and inconvenience that had suddenly arisen. Immediately, the Gas Company's Engineer (Mr. A. E. Broadberry) gave the necessary instruction for the lighting to be carried out; and within a very few minutes, the whole of the street-lamps (extending over an area of several square miles) were lighted, fully one-and-a-half hours before the schedule time. The inhabitants in the district must certainly be congratulated on having such an efficient system of lighting installed in their locality.

ELECTRICITY SUPPLY MEMORANDA.

THERE is a desire on our part to obtain acceptance, if possible, of the challenge made to Mr. Cramb, the Electrical Engineer of Croydon, to a competitive test with a metallic filament lamp and an inverted gas-burner of equal illuminating power (photometrically tested), using a unit of electricity and gas equal to the Croydon price of a unit of electricity for lighting, in order to make the conditions exactly comparable. We will say quite frankly that there are two reasons for wishing to get Mr. Cramb to accept this proposal. The first is that he has published certain cost figures as to the fair comparability of which no satisfaction has been given; and the second is that he is the Vice-Chairman of the Electricity Publicity Committee. The latter fact is a strong reason why he should accept the challenge. So far, there has been in respect of the challenge the old process of electrical evasion—evasion by silence on Mr. Cramb's part, and evasion by excuse in another quarter. "Meteor" of the "Electrical Times," under the pressure of our repeated references, has come out as spokesman, and has utilized an amount of puerile excuse for the non-acceptance of the competitive test by Mr. Cramb. He does not like the idea of the laboratory; he does not like the idea of the test being carried out under the auspices and conditions of a gas man; and he does not like the idea of Mr. Cramb's signed certificate as to the result being "hawked" about [*sic*] in 1917 or 1918. That is all interesting for its abject weakness and subterfuge. There is nothing about the test that "Meteor" does like. As we have previously said, there was no mention of the laboratory in our original conditions. But the exception taken to the laboratory, or photometer room, is singular. The point has been examined carefully all round for the purpose of ascertaining if there are any substantial grounds for objecting to it. The inverted gas-burner and the metallic filament lamp would be there tested under precisely the same conditions. Neither the photometer nor the meters would add to, or take from, the efficiencies and consumptions of the lamps; and the darkened walls of the photometer room would not assist the lamps by reflection.

"Don't Run Away."

What Are the Acceptable Conditions?

The objection as to the test being carried out under "a gas man's auspices and conditions" is not polite. The suggestion (we thought it was clearly understood) has been all the way through that the test should be carried out under the joint auspices of a gas man and an electrical man. It was never suggested that Mr. Cramb should, or would, sign the certificate as to the result without satisfying himself as to its accuracy. "Does our critic imagine," asks "Meteor," "that this or any other electrical engineer would be so foolish as to subscribe to a comparative test of mantles and glow lamps under a gas man's auspices and conditions?" We have never imagined anything of the kind; the foolishness lies in the question. The photometer, the meters, and a chronometer would decide the issues, under the joint supervision of that (according to the crabbed soul of "Meteor") embodiment of dishonesty a gas man, and that embodiment of chaste honour and integrity an electrical engineer. If, however, our conditions for the suggested test are not acceptable, what are the conditions to which Mr. Cramb would not deem it foolish to subscribe? There is the further point as to the "hawking" about of the signed certificate of the result. We have no doubt whatever that, before the test was carried out, we could obtain a promise from the Croydon Gas Company that they would not "hawk" about the result in 1917 or 1918, but would content themselves with 1913, and make it quite clear that the test referred to lamps of the present day. "Meteor" imagines that there is not "the remotest chance" of the acceptance by Mr. Cramb of the test. Perhaps he is right. But there is the chance now for that gentleman to set out the conditions on which he would be prepared to accept it. The one condition we should insist upon is that the certificate as to the result whatever its nature should be signed by Mr. Cramb, and that for a limited period at any rate there should be liberty to circulate it. If it is true that the metallic filament lamp gives light at a cheaper rate than the modern inverted gas-burner, Mr. Cramb ought not to refuse, but he ought to welcome, the test. That is a plain truth from which there is no escape.

Fradulent Metallics.

Bearing on the question of the efficiency of metallic filament lamps, we have on various occasions called attention to the results of tests of the modern types which show that their claimed efficiency is not that secured by independent testings. Several electrical engineers who do not desire to claim anything more than can be actually realized under the best circumstances have likewise made public avowal of the repugnance they feel over the misrepresentation. Mr. A. J. Makower has registered his protest in the "Electrician." He regards the present state of affairs as most unsatisfactory; and he is not at all happy over the fraud that is being perpetrated on the public. He talks of the "demoralizing effect" and other things; and there is no doubt that he acutely feels the position in which the electrical industry has landed itself in the matters of assumption and

misrepresentation. Mr. Makower is not one to take things for granted; he examines them on his own behalf. He has been testing the efficiencies of a considerable number of metallic filament lamps of various well-known makes; and the "most usual" efficiency for the metallic filament lamps at present on the market lies between 1·4 and 1·6 watts per horizontal (British) candle power. It is not infrequently found, he adds, that lamps claim higher consumptions than these. At an efficiency of 1·6 watts per British candle power, Mr. Cramb and "Meteor" will notice that a 50-candle power lamp would require a unit of electricity per 12½ hours. Mr. Makower proceeds to point out that, although reference to makers' catalogues would lead one to expect the efficiency of the lamps to lie between 1 watt and 1·25 watts per candle power, it is a comparatively rare occurrence to find lamps that give even as good an efficiency as the higher of these figures. Improved durability of filament and colour of the light do not justify the retention of the efficiency figures appearing in the catalogues. "The discrepancy between the specified and the actual performance of the lamps is of sufficient magnitude to be of importance to the public; and it cannot be held to be justifiable to supply a lamp giving 11-candle power to a customer who expects to get a 16-candle power lamp. Indeed, I have come across cases in which considerable trouble has resulted from this cause." And small wonder!

A Mean Action.

Touching this point as to misrepresentation of electric lamp values, it does not strike us as very courageous to do as the Chesham Electric Light and Power Company, Limited, have done in making an oblique attack upon the Chesham Gas Company. They have issued a large advertisement in the "Bucks Examiner," headed "Gas *v.* Electricity." Electricity is not referred to otherwise in the advertisement, except in the title of the Company; the matter being composed entirely of an extract from (so the advertisement runs) "one of the leading trade journals, 'Gas,'" of Aug. 7 last. The article from which the extract was taken was mainly an attack upon those manufacturers and others who make extravagant claims for gas-lamps. The opinion of the writer of the article was that this was "bordering on a public scandal;" and he stated that he would not be surprised if the Government sooner or later made the publication of such false statements by burner and lamp makers (as well as by gas authorities and their officials who are as guilty) a misdemeanour, punishable by a stiff fine. The Chesham Electric Light and Power Company, Limited, think that this is proper matter to use in their local commercial enterprise. So applied, it is an indirect attack upon the *bona fides* of the Chesham Gas Company in their business relations with their consumers. If the Chesham Gas Company have not been guilty of publishing statements regarding illuminating power that they cannot justify, then the publication of the advertisement in question is an oblique and mean slander upon them, and has been published for the sole purpose of doing them a trade injury. Have the Chesham Electric Light Company never heard of the electric lamp tests of such men as Mr. C. C. Paterson, Professor Morris, Mr. J. W. Bradley, Mr. Leon Gaster, Mr. Haydn Harrison, Mr. Makower [see preceding paragraph], and others, which go to show how short of truth fall the statements as to electric lamp values of not only the lamp manufacturers, but of electricity suppliers. We have met with literature circulated by the electricity supply industry which simply teems with misrepresentation—literature designed to develop business by playing upon public ignorance of these lighting matters. It is time the Chesham Electric Light and Power Company knew how to properly select the matter for their advertisements, without giving local application, for the purpose of injuring the trade interests of a competitor, to an indictment such as the one to which reference has been made, and which may not legitimately apply to the local gas company.

Efficacy in Illumination.

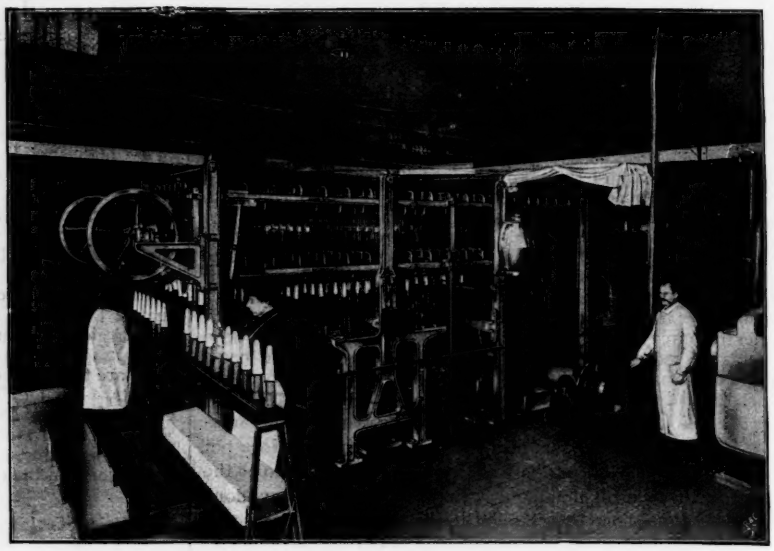
Too long the efficiency of lamps has been dwelt upon without taking into account the question of illuminating efficacy. But all this is now being changed, and at a considerable pace. The science of illumination is being studied more and more, and knowledge of the subject extends day by day. In fact, illuminating efficacy, which embraces hygienic and æsthetic considerations, has now been raised as a general criterion in the best illuminating practice. We are glad of it; and it is hoped that the gas industry will make the best of its opportunities, for of the two chief illuminants used to-day, gas holds the supreme place from the hygienic standpoint. These sentences are prompted by the reading of an article on the "Efficacy of Illumination" by Mr. D. S. Millar, published in the "Electrical World." In this article, the author calls attention to the marked advance there has been in the efficacy of the lighting auxiliaries which have followed close on the heels of the development of higher power units of lighting. These auxiliaries are largely the direct product of the higher efficiency lights of the present day—they are more the product of those higher efficiency lamps which require something to modify their defects than of those lamps which suffer less from baneful defects. All these auxiliaries—intensity minimizing and diffusing globes, and so forth—were not thought of in the days of low specific intensity lights; and it is only since the higher efficiency types of lamps have come upon us that we have learnt how much the fundamental principles of illumination were neglected in those former days. In these latter times, the gas industry has been under a distinct disadvantage in having lived in those days when the low specific intensity of artificial lights rendered less necessary the study of illumination problems and the correct application of light. The disadvantage has been found in the fact of a supreme contentment, and of neglect to thoroughly understand what a good thing gas lighting is in its modern forms in the matter of quality, and to make the broadest possible commercial use of the advantage. We have suffered much as an industry from this neglect; and it is the industry's business to see that it does not suffer any longer. Mr. Millar, in his article, says that the tungsten lamp, because of its high specific intensity and great candle power, demands shading more than the carbon filament lamp. Now we know that the intrinsic brilliancy of the tungsten lamp, per unit of area of the light source, is something like nine to ten times greater than that of the carbon filament lamp; and the intrinsic brilliancy of the carbon filament lamp is about five times greater than that of the low-pressure incandescent gas mantle. The intrinsic brilliancy of the high-pressure gas mantle is only about one-and-a-half times that of the carbon filament lamp. These facts show an important hygienic advantage on the side of gas; it shows, too, why there has been less call by gas-lamps than by electric-lamps for what are termed the auxiliaries of illumination to cure inherent defects. Light diffusion and direction of the rays are also in greater favour of the inverted gas-lamp than of any electric lamp. With all these merits in the matter of illumination efficacy in hand, the gas industry has to plead guilty to having largely neglected them in the commercial campaign.

Electric "Cooking."

Our electrical contemporaries are not of one mind as to the inclination of the public towards electrical cooking. Reading between the lines of an article in the "Electrician," those engaged in pioneer electric cooking work are finding public opinion of a somewhat adamant character; and it will require a tremendous amount of energy and force to break through it. Our contemporary holds that the electricity supply industry can only hope to make any real progress with this branch of business by properly organized cooking demonstrations; and it urges that "the time has surely come for us to put aside any notion that we can hope to shake the faith of the public in gas cooking without the aid of practical lectures and public demonstrations." What have the "Tricity" people been doing these many months since the unattractive-to-the-public Electrical Exhibition held at Olympia? Their example in sending men lecturers and demonstrators round the country is also being followed by other cooker firms. That this work has not been generously effectual is obviously the opinion of the "Electrician." But the "Electrical Times" sees things through different glasses. It often, in fact, looks at things through a microscope, and then presents the result to its readers. It has also the bad habit of giving a turgid appearance to its quantitative assertions. This contemporary finds there are ten districts in the country supplying electricity for cooking at ½d. per unit; and therefore it seems to it that there are indications of an electric cooking boom. It makes too long a story for it to tell its readers that most of the concerns that are charging ½d. per unit do not forget to also levy a predetermined fixed charge. There is also an omission in not explaining why such a low price as ½d. per unit is necessary for cooking purposes. Our contemporary further talks of many thousands of "Tricity" electric cookers being in daily operation. We do not think that "many thousands" is a proper term for the actual figure. Moreover, those that have been sent out are not all in daily use. There are within our knowledge, in the showrooms of certain electricity undertakings, a number that have had the dust removed from them daily from the day they took up their abode there. The same contemporary refers to "Modern Kitchens, Limited"—this is associated with the "Tricity" outfit exploiters—as having established the first public restaurant in London to use electricity throughout for *all* purposes—lighting, heating, cooking, and other domestic uses. It is understood that this restaurant (which is situated in Oxford Street) only deals with light luncheons and teas, and not dinners. Anyone wanting a dinner must go to one of the palatial dining establishments where the cooking is all done by using gas as the fuel. In another article in our contemporary, there is contradiction of its own statement that electricity is used for all purposes. There is a coke-fed water-boiler in the basement of the premises. Further qualification of the previous week's statement is found in the remark that the restaurant has been established for the purpose of popularizing "Tricity" cookers for domestic use, and that no attempt has been made to employ electricity for every incidental application apart from cooking. "Is boiling" merely an "incidental application" in cooking? We really opine not; and therein is one of the serious drawbacks of the electrical method. The remark is thrown in that "had it been desired, either the 'Therol' or 'Cooper' heat storage system could have been adopted to deal with the hot water supply, as is being done satisfactorily in other and similar cases." The "Tricity" people had very good reasons for adopting a coke-fed water-boiler—one of them being cost economy, and another rapidity of heating. B.Th.Us. tell in water heating and all other operations entailing the boiling of liquids. The "Electrical Times" knows the weakness of electricity in this regard; but it recks not of lapses in telling the tale, nor of the looseness of the part that it does tell. The electrical industry likes to play at self-deception; it believes that such tactics have a commercial value among the public.

MÜLLER AND BONNET'S MANTLE-MAKING MACHINE.

At the close of the second of the series of articles by Dr. C. Richard Böhm, of Berlin, on "The Manufacture of Mantles for Incandescent Gas Lighting," which appeared in the first three issues of the "Journal" for the present year, it was mentioned that efforts had been made to produce mantles from beginning to end entirely on machines. Herren Müller and Bonnet were credited with being probably the first to conceive this idea; and they took out copious patents covering the principles of the invention. A machine based upon these principles was brought out by Robin, and it is shown in the accompanying illustration. It led to patent litigation, which has only lately been brought to an end. The result has been to prove the practical value of Müller's bold idea; for it was stated by Dr. Böhm that in Germany alone many millions of mantles were manufactured on the Robin machines within the space of a few years. A number of these machines, which for several years were employed with highly satisfactory results at the works of Herr Richard Feuer in Berlin, had to be taken out on account of the patent litigation. We are pleased to be able to make this addition to Dr. Böhm's interesting communications.



COAL PRODUCTION OF THE WORLD.

Board of Trade Statistics.

Three weeks ago there were given in the "Journal" some particulars with regard to the output of coal in the United Kingdom during the year 1911; and to the information derivable from the Home Office Blue-Book may now be added some figures from the annual "Coal Tables," issued as a parliamentary paper by the Board of Trade, and bearing the signature of Mr. G. S. Barnes. In these tables there are collected figures (mostly for 1911, though some are provisional) relating to the production, consumption, and imports and exports of coal in the British Empire and the principal foreign countries, together with statements showing the production of lignite and petroleum in the principal producing countries. The statistics having reference to ordinary coal are set forth in a series of nineteen tables (of which three furnish particulars as to the quantities of coal used in gas manufacture and in the production of pig iron and for locomotive purposes, in the United Kingdom), while five relate to lignite and petroleum. Figures are also given as to the number of persons employed in mining, value of coal produced, &c. Throughout the tables, quantities are expressed in terms of the English ton.

The total known coal production of the world in 1911 (exclusive of brown coal or lignite) was about 1050 million tons, of which the United Kingdom produced more than one-fourth, and the United States more than two-fifths. The United States, the United Kingdom, Germany, France, and Belgium are the five principal coal-producing countries; and in the United Kingdom, Germany, and France the production in 1911 exceeded that of any previous year. In Belgium, on the other hand, it was less than in any of the five preceding years; while in the United States it fell short of the output of 1910 by 4¾ million tons. The aggregate output of the five countries was nearly 934 million tons in 1911, which was an increase of 11 million tons over the preceding year, and of 53 million tons over the figure of 1909. The increase in the production of the United Kingdom was nearly 7½ million tons, compared with 1910; and that of Germany about 7¾ million tons more. The figures for the past three years are as follows: United Kingdom—1909, 263,774,000 tons; 1910, 264,433,000 tons; 1911, 271,899,000 tons. Germany—1909, 146,397,000 tons; 1910, 150,372,000 tons; 1911, 158,164,000 tons (provisional). France—1909, 36,519,000 tons; 1910, 37,030,000 tons; 1911, 38,023,000 tons (provisional). Belgium—1909, 23,140,000 tons; 1910, 23,532,000 tons; 1911, 22,683,000 tons. United States—1909, 411,432,000 tons; 1910, 447,854,000 tons; 1911, 443,025,000 tons (provisional). Of the remaining countries included in the tables, Russia alone has a production exceeding 20 million tons.

Production per Head and Values.

The production of the United States in 1911 exceeded that of the United Kingdom by nearly 63 per cent.; but as compared with its population, the output of coal in the United Kingdom still surpasses that of the United States—being 6 tons per head, as compared with something under 5 tons. The output per head in Belgium is over 3 tons, in Germany nearly 2½ tons, and in France under 1 ton. As to the number of persons engaged in the coal-mining industry, it is seen that far more are employed in the United Kingdom than in any other country. In 1910, the number of persons employed in coal mining, above and below ground, in each of the principal producing countries was as follows: United Kingdom, 1,027,500; United States, 725,000; Germany, 621,100; France, 196,800; Belgium, 143,700. The conditions are, however, so varied in the different fields, that it is difficult to draw any comparisons from these figures. With regard to the output per person employed, this, again, is affected by different considerations. The United States took the first place in 1910, with an output of 618 tons per person employed; while the United Kingdom was second, with 257 tons. Then came Germany with 242 tons, France with 188 tons, and Belgium with 164 tons.

During recent years, the variations in the average value of coal at the pit's mouth in the United States have, it is stated, been comparatively small. On the other hand, the considerable rise in the average value which accompanied the largely increased output of 1907 in the principal European countries was in 1908 followed by further increases in Germany and France, but by reductions in the United Kingdom and Belgium. The average value fell in all four countries in 1909, but rose again in the United Kingdom and Belgium the following year. In 1911, there was a fall of ½d. per ton in the United Kingdom, and of 2½d. per ton in Germany, and a rise of 1¾d. per ton in Belgium, as compared with the preceding year. There has, it is pointed out, thus been a steady decrease in the average value in Germany during the last four years, and in France during the years 1908, 1909, and 1910; while fluctuations have occurred in the other countries. The following are the figures for the last two years: United Kingdom—1910, 8s. 2¼d.; 1911, 8s. 1¾d. Germany—1910, 9s. 11⅜d.; 1911, 9s. 9½d. (provisional). France—1910, 12s. 3½d.; 1911 (unstated). Belgium—1910, 11s. 10½d.; 1911, 12s. United States—1910, 5s. 10½d.; 1911, 5s. 10¾d. (provisional). But, as with the number of persons employed, the average values are influenced by various factors. For one thing, of course, the figures given are not all for coal of the same quality.

If the principal parts of the British Empire are considered, it is found that in three cases the annual output of coal now exceeds 10 million tons. The largest contributor for 1911 was British India, with 12,716,000 tons. Then came the Commonwealth of Australia with 10,550,000 tons, the Dominion of Canada with 10,082,000 tons, the Union of South Africa with 6,780,000 tons, and the Dominion of New Zealand with 2,066,000 tons. In Australia and South Africa the production was larger than in any previous year; but there was some falling off as compared with 1910 in the cases of Canada and New Zealand. The output per head of the population last year amounted to 2⅓ tons in Australia, slightly over 2 tons in New Zealand, 1⅛ tons in Canada, and 1⅓ tons in South Africa. In 1911 the average value of coal at the pit's mouth in the different parts was: British India, 3s. 11¼d. per ton; Australia, 7s. 5½d. (provisional); New Zealand, 10s. 10¼d. (provisional); Canada, 10s. 9d. (provisional); and South Africa, 5s. 8½d. In British India, South Africa, and Australia the average value of coal produced was lower, and in New Zealand and Canada higher, in each of the years 1909 to 1911 than in this country.

Imports and Exports.

Some consideration is given in another section of the tables to the question of imports and exports; and from this it is gathered

that the foreign countries which export coal in excess of the amount they import are Germany, the United States, and Japan; while the same remark applies to the United Kingdom, Australia, South Africa, British India, and New Zealand. The excess of exports over imports in 1911 were as follows: United Kingdom, 87,040,000 tons; Germany, 24,727,000 tons; United States, 17,603,000 tons; Japan, 5,001,000 tons; Australia, 3,134,000 tons; South Africa, 1,299,000 tons; British India, 543,000 tons; and New Zealand, 36,000 tons. The exports from the United Kingdom, Germany, and the United States were greater in 1911 than in any other year; the increases, compared with 1910, being over 2½ million tons from the United Kingdom, nearly 4¼ million tons from Germany, and nearly 3¾ million tons from the United States. Excluding coke, patent fuel, and bunker coal, the total quantity of coal exported from the United Kingdom during the year 1911 was 64½ million tons, compared with a little over 62 million tons in 1910. The imports of coal into Germany last year amounted to nearly 12 million tons, more than three-fourths of which were obtained from the United Kingdom. The chief coal-producing foreign countries which imported coal in excess of the amount they exported were Russia, Sweden, France, Belgium, Spain, and Austria-Hungary. Italy (which is almost entirely dependent on imports) and Canada also come into this division.

The consumption of coal in each country is arrived at, for the purposes of the tables, by adding the imports to the home production, and deducting the exports. The figures given show that the total consumption of coal in the United States is now considerably more than twice as great as that in the United Kingdom, which has the next largest consumption; and during the last three years it was more than equal to the combined consumption of the United Kingdom, Germany, France, and Belgium. In the United Kingdom, the consumption in 1911 was nearly 5 million tons more than in the preceding twelve months, and over 6½ million tons more than the average for the years 1906-10. The chief coal-consuming countries last year, with the approximate amounts used were: United States, 425,422,000 tons; United Kingdom, 184,859,000 tons; Germany, 133,437,000 tons; France, 57,133,000 tons; Russia, 28,298,000 tons; and Belgium, 24,126,000 tons. It is pointed out that the coal consumption in the United States is also greater in proportion to the population than in the United Kingdom; while Belgium and Germany are the only other foreign countries in which the consumption per head exceeds 2 tons per annum—other fuels being largely used. The consumption per head for different countries, in 1911, is given as follows, though the figures are mostly provisional: United Kingdom, 4·08 tons; United States, 4·54 tons; Belgium, 3·21 tons; Germany, 2·03 tons; France, 1·44 tons; and Russia, 0·17 ton. Last year, 99·98 per cent. of the coal consumed in the United Kingdom was of native production; and in the United States, 99·68 per cent. In the case of Germany, 91·08 per cent. was native, 6·96 per cent. British, while 1·96 per cent. was from other sources. In France, 63·55 per cent. was native, 15·86 per cent. British, and 20·59 per cent. from other sources. The quantity of British coal imported into Germany for consumption in 1911 amounted to 9¼ million tons, compared with 9½ million tons the preceding year.

Coming to other matters, it may be mentioned that, in 1910, the production of lignite in Germany was 68,430,000 tons, in Austria 24,729,000 tons, and in Hungary 7,610,000 tons. The output in Austria in 1911 was 24,859,000 tons; while the provisional figures which are available show a production of 72,575,000 tons in Germany. The lignite produced in the United States is included in the coal figures. As to petroleum, the total production of the United States in 1911 was 7713 million gallons, as compared with 7332 million gallons in the preceding year. The oil-fields of Russia yielded 2424 million gallons in 1910, which was more by 108 million gallons than the quantity shown by the provisional figures for 1911. The combined output of Germany, Austria, Roumania, Japan, Canada, British India, and the Dutch East Indies was 1421 million gallons in 1910, and 1511 million gallons in 1911. Considerable advance in the industry has, it is stated, been made in Trinidad in the last few years.

Coal Used by Gas Undertakings in the United Kingdom.

The total quantity of coal carbonized by gas undertakings in the United Kingdom each year from 1906 to 1910 inclusive was:

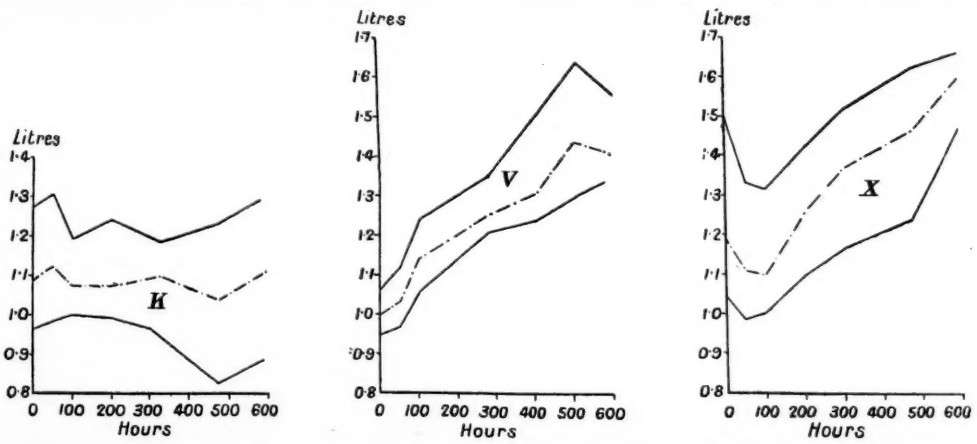
—	1906.	1907.	1908.	1909.	1910.
	Tons.	Tons.	Tons.	Tons.	Tons.
Companies . . .	8,922,781	9,240,280	9,281,738	9,175,532	9,236,081
Local authorities*.	5,923,476	6,166,473	6,112,569	6,049,788	6,161,702
Total. . .	14,846,257	15,406,753	15,394,307	15,225,320	15,397,783

* Twelve months ended March of the years following those stated.

INCANDESCENT MANTLES AND THEIR LIGHTING EFFICIENCY.

Readers of the "Journal" may remember that at the last meeting of the Société Technique du Gaz a paper on "Comburimetry" was submitted by M. André Grebel; and it gave rise to a discussion in which the author and M. Sainte-Claire Deville, the Chief Chemist of the Paris Gas Company, had a rather sharp passage-of-arms. It is not necessary to enter fully into the matter on which the two speakers differed; but it bore upon the efficiency of incandescent mantles. As the outcome of the discussion, M. Grebel was led to carry out some experiments with three lots of six silk mantles from different factories; and he gave the results in a recent number of the "Journal de l'Eclairage au Gaz." They are shown in the accompanying diagrams, in which the solid lines represent the extreme, and the broken lines the average, results, in litres of gas, obtained per horizontal candle-hour. The 80-litre burners were perfectly regulated at starting (corresponding, with a pressure of 50 mm., or 20-10ths, to a full intake of primary air), and not touched afterwards. The mantles were all placed at the same height. The measurements, made every hundred hours, were perfectly comparable; the quality of the gas being constant for each set of six results, which were themselves the averages of several measurements.

The curves X apply to mantles insufficiently burnt-off, which



Diagrams showing the Variations in Consumption of Gas per Horizontal Candle-Hour in Relation to Time of Burning.

complete this process with the user. The curves V refer to mantles which were at first relatively brilliant, but soon deteriorated. The curves K relate to sufficiently constant mantles, giving, in general, the best average results.

What relation is there, inquires M. Grebel, between the variations of efficiency in the time of burning and the weight, composition, texture, mode of manufacture, and burning-off of mantles? He considers that, so far, this is a mystery. In a general way, however, he says we know that the efficiency of mantles varies in inverse proportion to their life. Thus the averages given by small high-power vertical burners, fitted with mantles having a life of 600 hours and more, are the horizontal candle-hour with 1 litre of gas, the lower hemispherical candle-hour (without reflector with 1·1 litres, and the spherical candle-hour with 1·2 litres. With short-lived "photometric" mantles, the specific consumption, per horizontal candle-hour, may fall below 0·9 litre, and with very long-lived mantles it often exceeds 1·5 litres. High-pressure burners, with mantles of 40 hours' life, consume 0·6 litre of gas per lower hemispherical candle-hour, or about 1·2 litres per spherical candle-hour. With mantles of 200 hours' life, consumptions amount respectively to about 1 and 2 litres; while with those of 400 hours' life, 1·5 litres per lower hemispherical candle-hour, and not much less than 3 litres per spherical candle-hour, must be reckoned.

SURFACE COMBUSTION.

By William Arthur Bone,

Professor of Chemical Technology in the Imperial College of Science and Technology, London.

[A Lecture delivered before the German Chemical Society, Berlin, at their Meeting on Nov. 30, 1912.]

Surface Combustion.

It is to the genius of Sir Humphrey Davy that we owe (in 1817) the original discovery of the influence of hot metallic surfaces in promoting combustion. In his classical experiments upon the ignition of gases, he had found (what is now a matter of common knowledge) that the constituents of a combustible mixture will combine, slowly, below the actual ignition temperature. This led him to inquire whether, seeing that the temperatures of flames exceed those at which solids become incandescent, a metallic wire can be maintained at incandescence by the slow combination of two gases, without actual flame. He, therefore, tried the effect of introducing a warm platinum wire into a jar containing a mixture of coal gas and air, rendered non-explosive by an excess of the combustible constituents. The wire immediately became red-hot, and remained so until nearly the whole of the oxygen had disappeared. In subsequent experiments, Davy proved that hydrogen is far more susceptible to such surface combustion than either ethylene or carbon monoxide; also, that the power of inducing the phenomenon is by no means confined to metals of the platinum group, which, however, exhibit it in an eminent degree.

In 1823, the subject was investigated systematically by Dulong and Thénard, and independently also by Döbereiner, who proved that all solids, when sufficiently heated, possess the power of accelerating the slow combustion of gases below their ignition points, in varying degree according to their chemical character and fineness of division. It was found that platinum sponge will bring about the combination of hydrogen and oxygen (detonating gas) at the ordinary temperature; finely divided silver and gold become active at 150° and 250° respectively; whilst fragments of non-metallic substances, such as charcoal, pumice, porcelain, or glass, exhibit incipient activity at about 350°. It was further observed that the activity of platinum diminishes on exposure to the atmosphere—more quickly in moist than in dry air and is, moreover, completely destroyed by exposure to ammonia. It may, however, be restored by ignition and subsequent cooling out of contact with air.

In 1825, William Henry observed that when a platinum ball is immersed in a mixture of equal volume of detonating gas ($2H_2 + O_2$) and ethylene, the hydrogen alone was burnt, which important observation was confirmed by Graham in 1829. Various explanations of the phenomenon were put forward by these early investigators. Davy himself suggested an electrochemical one: "Supposing," he wrote,

> "oxygen and hydrogen to be in the relation of negative and positive, it is necessary, to effect their combination, that their electricities should be brought into equilibrium or discharged. This is done by the electrical spark or flame, which offers a conducting medium for this purpose, or by raising them to a temperature in which they become themselves conductors. Now platinum, palladium, and iridium are bodies very slightly positive with respect to oxygen. . . . They offer to the gases the conducting medium necessary for carrying off, and bringing into equilibrium, their electricities without any intervening energy, and accumulate the heat produced by this equilibrium."

Döbereiner, who discovered that freshly prepared platinum black absorbs oxygen from the air, and that in this "oxygenated" condition it will cause steam to be formed when plunged into a jar of hydrogen, contended that the metal merely acts as a carrier of oxygen. On the other hand, Fisinieri [1825] maintained that it is the combustible gas (hydrogen) only which is affected by the surface, being condensed and rendered extraordinarily active by association with the surface.

The matter formed the subject of a celebrated controversy between Faraday and De la Rive in 1834-35. De la Rive strongly upheld the view that surface combustion essentially consists of a series of rapidly alternating oxidations and reductions of the catalyzing material. Faraday, whilst not denying that finely-divided platinum absorbs oxygen, argued with great force that true surface combustion involves an action quite distinct from that of an oxidized wire or foil upon a combustible gas. The function of the solid is, he contended, to condense both the oxygen and the combustible gas at the surface—thus producing a condition in the surface layer comparable with that of high pressure.

It is important to observe here that, with the exception of Davy's original experiment on the glowing of a platinum wire in a non-explosive mixture of coal gas and air, none of these early investigators appear to have experimented with incandescent surfaces, nor (with the exception of the celebrated Döbereiner lamp) was there any technical outcome of their efforts. In 1836, interest in the subject waned, and was not revived for upwards of fifty years.

A notable demonstration of the possibility of realizing a flameless incandescent surface combustion in contact with metals other than those of the platinum group was given by Thomas Fletcher in a lecture at the Manchester Technical School as far back as 1887.* He injected a mixture of gas and air on to a large ball of iron wire—flame being used at first, in order to heat the wire to the temperature necessary to induce a continuous surface combustion. On extinguishing the flame by momentarily stopping the gaseous mixture, the combustion continued without any flame but with an enormous increase of temperature. Fletcher recognized that

> "This invisible flameless combustion is only possible under certain conditions; and one essential point is that the combustible mixture shall come into absolute contact with a substance at a high temperature," . . . and further that "in the absence of a solid substance at a high temperature, it is impossible to cause combustion without flame."†

But, so far as I am aware, he did not follow up the matter beyond this point, either in its theoretical aspects or practical applications; and his work had but little influence upon contemporary opinion or practice. This, perhaps, was hardly to be wondered at in an age dominated by the genius of Frederick Siemens, whose favourite dictum it was that hot surfaces by promoting dissociation must necessarily hinder combustion—a doctrine which, I venture to think, would find no credence amongst chemists to-day. For if an incandescent surface accelerates the dissociation of steam, it must—according to a principle first enunciated by Ostwald—of necessity accelerate the combination of hydrogen and oxygen in like degree, provided the catalyst remains itself unaltered.

It is now generally recognized by chemists as a well-established principle that all hot surfaces have an accelerating influence upon chemical changes in gaseous systems; or, in other words, that if at any temperature a gaseous system "A" tends to pass over into another system "B," contact with a solid at the same temperature will accelerate the process.

To take a very simple example, if a mixture of hydrogen and oxygen in their combining proportions (electrolytic gas) be maintained in an enclosure with smooth glass walls at a temperature of (say) 450° C., there would certainly be a tendency to form steam; but the rate of change would be negligibly small. If, however, there be brought into the system some porous solid material at the same temperature, so that a large surface is exposed to the gases, the rate of change would at once be rapidly accelerated in the layer of gas immediately in contact with the hot surface. Steam, the product, would diffuse outwards from the surface; and the supplies of hydrogen and oxygen at the surface would be renewed by diffusion inwards. Thus combustion would proceed heterogeneously at the surface until the transformation of the original electrolytic gas into steam was complete. In the circumstances just cited, the rate of combustion, although now quite measurable, would probably be insufficient to cause any self-heating of the enclosure. The temperature would remain at 450° C., which is well below either the ignition temperature of the combustible mixture or the point at which a solid would attain even incipient incandescence.

It is therefore necessary to distinguish between two possible conditions under which gaseous combustion may occur—(1) *Homogeneously*—that is to say, equally throughout the system as a whole, at temperatures *below* the ignition points *slowly* and *without flame*, and at temperatures *above* the ignition point *rapidly* and *with flame*; and (2) *Heterogeneously*, or only in layers immediately in contact with a hot or incandescent surface ("surface combustion"). It is also necessary to remember that, *ceteris paribus*, the heterogeneous surface combustion is a faster process than the normal homogeneous combustion of ordinary flames.

My own investigations upon surface combustion began in 1902 with a systematic attempt to elucidate the factors operative in the slow combination of hydrogen and of carbon monoxide with oxygen in contact with various hot surfaces (*e.g.*, porcelain, fire-clay, magnesia, platinum, gold, silver, copper and nickel oxides, &c.) at temperatures below 500°.‡ For this purpose an apparatus was devised for the continuous circulation of the reacting mixture at constant rate over the catalyzing surface contained in a combustion tube, and maintained at a constant temperature. Suitable arrangements were made for the rapid removal of the reaction product (H_2O or CO_2) from the system; and therefore the rate of combination could be deduced from pressure readings at frequent time intervals.

In interpreting the results of such velocity measurements, the following factors must be considered: (1) The actual rate of combination at the surface; (2) diffusion rates; (3) the rates at which the reacting gases, or either of them, are rendered "active" by the surface; and (4) changes, if any, in the physical texture of the surface itself. Of these factors, the actual rate of combination at the surface usually far exceeds either (2) or (3), and the amount of change observed in the system in unit time will obviously be governed by whichever of these is the slowest in its operation under given conditions.

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* "Journal of Gas Lighting," 1887 (1), p, 168. † *Ibid.*

‡ Bone and Wheeler, "Phil: Trans: Roy. Soc." 1906, A. 206, pp. 1-67; also further [unpublished] results (1905-1912) in collaboration with G. W. Andrew, A. Forshaw, and H. Hartley.

Although certain points connected with the inner mechanism of the catalytic process are not yet fully elucidated, the results of the investigation prove that it depends primarily upon the condensation or absorption of one or other (and possibly both) of the reacting gases by the surface, whereby they are rendered "active," probably by ionization. Any purely chemical explanation—such, for example, as the supposition of a rapidly alternating series of oxidations and reductions of the surface—is inconsistent with the numerous velocity measurements recorded during the research. Equally certain is it that the rate of combustion at these low temperatures is not usually governed by "diffusion factors," as Nernst has suggested, but by the rate of "activation" of one or other of the reacting gases (and usually of the combustible gas) by the surface.

The catalyzing power of a new surface at a given temperature usually increases up to a steady maximum, when successive charges of the reacting gases, mixed in their combining ratios, are circulated over it. After the attainment of this steady condition, the rate of combination is always directly proportional to the pressure, provided that the gases are present in their combining ratios, and the product of combustion is rapidly removed from the sphere of action. Where, however, one or other of the reacting gases is present in excess, the rate of combustion is usually proportional to the partial pressure of the combustible gas—*e.g.*, hydrogen or carbonic oxide—which thus becomes the ruling factor. The behaviour of copper oxide towards mixtures of hydrogen with excess of oxygen, and of nickel oxide towards mixtures of carbon monoxide with excess of oxygen, have so far proved exceptional in this respect; the observed rates in both cases being more nearly proportional to the partial pressure of the oxygen than to that of the combustible gas. In the case of copper oxide, there is definite proof of the formation of a condensed film of "active" oxygen at the surface, which actually burns up the hydrogen before it can reach the still more active oxygen chemically combined with the copper.

The catalyzing powers of all the metallic and non-reducible oxide surfaces examined are highly stimulated by previous exposure to the combustible gas, which is undoubtedly rendered "active" by association with the surface. This stimulus is usually very durable; but in most cases it is at once destroyed by a short exposure to oxygen. Although, as a general rule, oxygen has *per se* no stimulating effect on a catalyzing surface, cases to the contrary have been encountered. But, even in these exceptional instances, the effect is neither so marked nor so durable as the corresponding effects always observed in respect of the combustible gas.

In illustration of the foregoing statements, a series of experiments in which mixtures of hydrogen and oxygen in varying proportions were circulated over porous porcelain maintained at a constant temperature of 430° may be quoted:—

I.—*March* 14, 1904. *Electrolytic Gas. Surface in "Normal Condition."*

Time in Hours.	0.	2.	4.	6.	8.	10.	12.	14.
Pressure of dry gas in mm.	411·8	343·3	283·5	230·3	188·5	155·6	126·2	106·0
K.	—	0·0395	0·0405	0·0420	0·0420	0·0422	0·0424	0·0422

II.—*April* 26, 1904. *Original Mixture* = $H_2 + O_2$ (*Approx.*).

Time in Hours.	0.	2.	4.	6.	8.	12.	24.	28.	32.
PH_2	196·0	169·2	150·2	126·5	109·5	82·7	35·1	25·3	16·5
PO_2	202·0	188·8	179·3	167·5	158·9	145·6	121·8	116·8	112·5
KH_2	—	0·0320	0·0289	0·0317	0·0316	0·0312	0·0311	0·0318	0·0335
KO_2	—	0·0148	0·0130	0·0136	0·0131	0·0119	0·0092	0·0085	0·0080

Rate of combination proportional to PH_2 and *slower* than in I.

III.—*April* 29, 1904. *Original Mixture* = 3 H_2 + O_2 (*Approx.*).

Time in Hours.	0.	2.	4.	6.	8.	10.	12.	14.	16.	18.
PH_2.	292·5	260·5	230·5	206·2	185·9	167·8	151·8	137·1	123·6	111·4
PO_2.	94·9	78·9	63·9	51·8	41·7	32·6	24·6	17·3	10·4	4·4
KH_2	—	0·0253	0·0259	0·0253	0·0246	0·0241	0·0237	0·0235	0·0240	0·0233
KO_2.	—	0·0401	0·0429	0·0438	0·0447	0·0464	0·0488	0·0528	0·0600	0·0741

Rate of combination proportional to PH_2 and *faster* than in I.

IV.—*May* 3-31, 1904. 2 $H_2 + O_2$. *Showing Effects of Alternating Long Exposure of the Surface to Either* H_2 *or* O_2 *at* 430° *C. upon its Catalyzing Power.*

(*a*) Surface previously exposed to H_2 24 hours . . K = 0·0515
(*b*) " " " " O_2 24 " . . K = 0·0305
(*c*) " " " " H_2 40 " . . K = 0·0592
(*d*) " " " " O_2 48 " . . K = 0·0373
(*e*) " " " " H_2 72 " . . K = 0·0622

"K" for surface in normal condition = 0·0430.

Later experiments have established certain differences between "homogeneous" combustion in ordinary flames and "heterogeneous combustion in contact with a hot surface, two of which I may mention as of special interest from a theoretical standpoint.

My recent researches upon "flame" combustion have proved that methane combines with oxygen much more energetically than does hydrogen—the relative affinities of these two gases for oxygen under such conditions being approximately as 20 to 1. But in "surface combustion," for example, in contact with hot fire-clay, this order is completely reversed—due no doubt to some "selective" action of the surface in "ionizing" or rendering the two combustible gases active. This fact is strikingly proved by the results of an experiment in which a mixture originally corresponding to $CH_4 + 2H_2 + O_2$ was circulated over a hot fire-clay surface at 500°, until nearly the whole of the original oxygen had disappeared. The complete reversal of the relative rates of oxidation of methane and hydrogen under the influence of the hot surface, as compared with those observed in homogeneous "flame" combustion, will be at once apparent from the partial pressures of the three constituents at time intervals 0, 3, and 6 hours, respectively, during the experiment tabulated below:—

Time in Hours.	PCH_4	PH_2.	PO_2.	Percentage Burnt in each Three Hours' Interval.	
	mm.	mm.	mm.	CH_4.	H_2.
0	129·7	249·1	128·6	12·5	56·0
3	113·4	109·8	37·1		
6	102·6	50·6	4·7	9·5	53·0

The second difference referred to relates to the influence of steam upon the combustion of carbon monoxide. I need hardly remind you how the brilliant researches of Harold B. Dixon in 1881 proved that the presence of steam greatly accelerates, if it is not essential to, the homogeneous combustion of carbon monoxide. A mixture of carbon monoxide and oxygen, dried by long contact with phosphoric anhydride, will not explode when sparked in the usual way in an eudiometer, whereas the presence of the merest trace of moisture at once makes the mixture explosive. But, in contradistinction to this, I have recently proved that the rate of combination of a mixture $2CO+O_2$ in contact with fire-clay at 500° is doubled by the elimination of steam—a circumstance probably due to some "ionizing" effect of the hot surface upon the reacting gases, which is in some (as yet unknown) way counterbalanced by the presence of steam.

The fact that catalytic combustion depends upon an intimate "association" of the surface with the combining gases may be further illustrated by two very striking photomicrographs of the surface of a silver gauze taken before and after a long series of experiments in which it was employed as the catalyzing medium for the combination of hydrogen and oxygen at 400°. The first shows the original smooth condition of the surface, the second shows a beautifully "frosted" surface produced by the deep "pitting" action of the reacting gases during their absorption and "activation" by the metal. Incidentally, also, I may remark that our experiments have proved that such a surface became strongly negatively electrified during the catalytic combustion.

My next contention is that if hot surfaces possess the power of accelerating gaseous combustion at temperatures below or in the neighbourhood of the ignition point, the same power must also be manifested in even a greater degree at higher temperatures, and especially so when the surface itself becomes incandescent. Indeed, there are experimental grounds for the belief that not only does the accelerating influence of the surface rapidly increase with the temperature, but also that the differences between the catalyzing powers of various surfaces, which at low temperatures are often considerable, diminish with ascending temperatures until at bright incandescence they practically disappear. This conclusion is reinforced in an interesting manner by Knietsch's proof that in the formation of sulphuric anhydride (SO_3) from sulphur dioxide and oxygen, there is little difference between the catalyzing powers of platinum and broken porcelain at 850°, although at this temperature the catalyzing effect is of no technical importance, owing to the rapid dissociation of SO_3.

Assuming, therefore, the validity of this conclusion, it may be profitable for us to consider for a moment how far it is possible to accelerate the process of combustion in an ordinary flame. We are apt to think of ordinary flame combustion as an instantaneous process, whereas when considered in terms "molecular time," it is a very slow transaction. Thus, for example, when electrolytic gas is ignited by a spark near the closed end of a tube, the flame is initially propagated by conduction, with a uniform slow velocity of 20 metres per second. During this preliminary period of "inflammation," the total duration of chemical change in each successive layer of gas is something like the order of one-fiftieth part

of a second—an interval at least one hundred million times as long as the average interval between successive molecular collisions in electrolytic gas at the ordinary temperature.

After the flame has travelled a short distance along the tube, it is rapidly accelerated, under the influence of compression waves reflected from the closed end of the tube, until a new condition known as "detonation" is set up. In "detonation," the flame is propagated through the mixture by adiabatic compression at an enormously great and constant velocity, amounting in the case of electrolytic gas at atmospheric pressure to no less than 2820 metres per second. The combustion now proceeds under conditions of maximum intensity, both as regards the actual duration of chemical change and the temperatures produced in each layer of the burning gases. Some years ago, in conjunction with Dr. Bevan Lean, I found that the duration of chemical action in each successive layer of electrolytic gas in which "detonation" has been determined does not exceed one-five-thousandth or possibly one-ten-thousandth part of a second*—*i.e.*, an interval less than one-hundredth of the corresponding duration in an ordinary flame ("inflammation" with the same mixture).

In order to give you visual evidence of the validity of this conclusion, I will throw on the screen a photograph taken by Professor Harold B. Dixon, of Manchester, of the progress of an explosion in a mixture of cyanogen and oxygen, $C_2N_2 + 2 - O_2$, its origin, at a point a few centimetres from the closed end of a horizontal glass tube up to the attainment of its maximum force and intensity in detonation.† The flame was photographed on a highly sensitive film moving vertically at a velocity of about 50 metres per second; and the graph thus traced on the film was, therefore, compounded of the horizontal velocity of the flame along the tube, and the vertical velocity of the film. You will observe that the flame was initially propagated through the explosive mixture with a comparatively slow uniform velocity. Its luminosity during this initial period of "inflammation" (which corresponds to the conditions of ordinary flames) was comparatively feeble; and, from the slope of the graph, it is evident that its velocity was much slower than that of the vertical motion of the film. After traversing about 0·5 metre along the tube, its velocity was accelerated, and simultaneously the intensity of the combustion increased, as is indicated in the photograph by a brightening of the flame. The acceleration of the flame continued until, at a point just beyond the reference mark, "detonation" was set up. At this juncture the flame suddenly increased in brilliance, and dashed forward through the mixture at a velocity many times greater (as a matter of fact, more than fifty times) than the vertical velocity of the film. At the same instant a strongly luminous wave of compression (called the "retonation wave") was sent backwards through the still burning gases. The luminous track of this "retonation wave" is to be ascribed to its accelerating influence upon the residual combustion in a mixture which had already been "inflamed;" and it is evident from the photograph that this afterburning continued even after the "retonation wave" had been reflected back again from the closed end of the tube. Whilst this photograph has no direct bearing upon the question of surface combustion, it nevertheless proved beyond all question that the conditions prevailing in ordinary flames are such as admit of a great acceleration, and therefore intensification of the combustion by the action of an incandescent surface.

Such considerations as I have thus briefly explained convinced me some years ago that if an explosive gaseous mixture be either injected on to or forced through the interstices of a porous refractory incandescent solid under certain conditions, which will be hereafter explained, a greatly accelerated combustion would take place within the interstices or pores, or, in other words, within the boundary layers between the gaseous and solid phases wherever these may be in contact; and the heat developed by this intensified combustion would maintain the surface in a state of incandescence without any development of flame—thus realizing the conception of "flameless incandescent surface combustion" as a means of greatly increasing the general efficiency of heating operations wherever it can be conveniently applied.

There are two further points which I particularly wish to make clear to you. In dealing with gaseous interactions at high temperatures, it is necessary to think in terms of what I may call "molecular" dimensions. Our ordinary units of time, space, and mass are altogether too gross, and must be discarded if we would wish to form a true mental picture of the mechanism of combustion. When, therefore, I speak of combustion as occurring "within the interstices or pores" of an incandescent solid, it must be understood that I mean "porosity" in a molecular sense. A solid may appear to the eye to be dense and yet be highly permeable to the molecules of a gas. From this point of view, it is only vitreous surfaces—such as glass—which are (relatively speaking) non-porous to gases, and even glass when it becomes devitrified is sufficiently porous to induce a slow surface combustion.

In the second place, I want to emphasize the fact that the incandescent solid plays a specific rôle in this surface combustion. It is no mere idle "looker-on" at the surging crowd of reacting molecules which swarm around it. On the contrary, it so galvanizes and incites the dormant affinities between the combustible gas and the oxygen, that the "stately minuet" of ordinary flame combustion gives place to the "wild intoxication" of the Venusberg. The manner in which the surface acts is still perhaps a matter of conjecture; but the fact that it so acts can no longer be disputed. In a discussion which took place at the British Association in 1910, Sir J. J. Thomson insisted that combustion is concerned not only with atoms and molecules, but also with electrons—*i.e.*, bodies of much smaller dimensions and moving with very high velocities; and he suggested that, in reference to the influence of hot surfaces in promoting combustion, it was not improbable that the emission of charged particles from the surface was a factor of primary importance.* It is known that incandescent surfaces emit enormous streams of electrons travelling with high velocities; and the actions of these surfaces in promoting combustion may ultimately be found to depend on the fact that they bring about the formation of layers of electrified gas in which chemical changes proceed with extraordinarily high velocity.

The New Processes of Incandescent Surface Combustion.

Leaving the theoretical aspects of the subject, I will now describe some of the more important features of two processes of "incandescent surface combustion" recently evolved in Leeds under my direction, in which a homogeneous explosive mixture of gas and air, in the proper proportions for complete combustion (or with air in slight excess thereof), is caused to burn without flame in contact with a granular incandescent solid, whereby a large proportion of the potential energy of the gas is immediately converted into radiant form. The advantages claimed for the new system are: (1) The combustion is greatly accelerated by the incandescent surface, and if so desired may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air; (3) the attainment of very high temperatures is possible without the aid of elaborate "regenerative" devices; and (4) owing to the large amount of radiant energy developed, transmission of heat from the seat of combustion to the object to be heated is very rapid. These advantages are (as I believe) so uniquely combined in the new system that the resultant heating effect is, for many important purposes not only pre-eminently economical but also easy of control.

Diaphragm Heating and its Applications.

In the first process, the homogeneous mixture of gas and air is allowed to flow under slight pressure through a porous diaphragm of refractory material from a suitable feeding-chamber, and is caused to burn without flame at the surface of exit, which is thereby maintained in a state of red-hot incandescence. The diaphragm is composed of granules of fire-brick bound together into a coherent block by suitable means. The porosity of the diaphragm is graded to suit the particular kind of gas for which it is to be used; but for undiluted coal gas, or coal gas containing only a small proportion of water gas, a diaphragm so porous that the gaseous mixture will readily flow through it at a pressure of 3 to 5 inches water-gauge is employed. The diaphragm is mounted in a suitable casing; the space enclosed between the back of the casing and the diaphragm constituting a convenient feeding-chamber for the gaseous mixture which is introduced at the back. Such a mixture may be obtained in either of two ways: (1) By means of suitable connections through a Y piece with separate supplies of low-pressure gas and air (6 cm. water-gauge is sufficient); or (2) by means of an "injector" arrangement connected with a supply of gas at a pressure of 1·15 kilos per sq. cm. The gas in this case draws in its own air from the atmosphere in sufficient quantity for complete combustion—the proportions of gas and air being easily regulated by a simple device.

To start-up a diaphragm, gas is first of all turned on, and ignited as it issues at the surface. Air is then gradually added until a fully aërated mixture is obtained. The flame soon becomes non-luminous, and diminishes in size. A moment later, it retreats on to the surface of the diaphragm, which at once assumes a bluish appearance. Soon, however, the granules at the surface attain an incipient red heat, producing a curious mottled effect. Finally, the whole of the surface layer of granules becomes red hot, and an accelerated "surface combustion" comes into play. All signs of flame disappear, and there remains an intensely glowing surface—a veritable wall of fire but without flame—throwing out a genial radiant heat, which can be steadily maintained for as long as required. We will now start-up one of the diaphragms on the table; and you can judge for yourselves both of the quickness of the operation (it takes but a minute or two after starting-up to attain full red heat) and of the beauty of the radiant effect produced. No one, I imagine, can see one of these diaphragms in operation and remain a disbeliever in the fact and potency of "surface combustion."

Whilst the diaphragm is in operation before you, I may point out some of the more striking features of the phenomenon which it presents. Firstly, the actual combustion is confined within a very thin layer (a few mms. only) immediately below the surface; and no heat is developed in any other part of the apparatus. Kindly observe that, whilst the front of the diaphragm is intensely hot, the back of the apparatus is so cold that I can lay my hand upon it. Secondly, the combustion of the gas, although confined within such narrow limits, is perfect; for when once the relative proportions of gas and air have been properly adjusted, no trace of unburnt gas escapes from the surface. Thirdly, the temperature at the surface of the diaphragm can be instantly varied at will by altering the rate of feeding of the gaseous mixture. There is practically no lag in the temperature response—a circumstance

* "British Association Reports," 1892, p. 685.
† "Phil. Trans. Roy. Soc.," 1903 [200 A], 343.

* "British Association Reports," 1910, p. 501.

of great importance in operations where a fine regulation of heat is required. The temperature of a diaphragm working on a coal gas and air mixture, at a given rate of feeding, depends on whether or not the intense radiation from its surface is impeded. With a freely radiating surface, the temperature of a properly-made diaphragm may be maintained at anything up to about 850° C., according to the rate of supply of the combustible mixture. Fourthly, a plane diaphragm such as this may be used in any position—*i.e.*, at any desired angle between the horizontal and vertical planes. Fifthly, the diaphragm method is amenable to a variety of combustible gases, coal or coke-oven gas (either undiluted or admixed with water gas), natural gas, petrol-air gas, carburetted water gas, are all well suited in cases where unimpeded radiation is required. Finally, the incandescence in no way depends upon the external atmosphere. When once the diaphragm has become incandescent, and the proportions of air and gas supplied in the mixing chamber at the back have been properly adjusted, the surface will maintain its incandescence unimpaired even in an atmosphere of carbon dioxide.

I need hardly point out to you the many obvious purposes to which "diaphragm heating" may be applied. It will suffice if I afterwards demonstrate to you one of special interest to chemists, inasmuch as it relates to the evaporation and concentration of liquids by means of radiant energy emitted from a diaphragm fixed in a horizontal plane above the surface of the liquid. By means of a diaphragm mounted so that its incandescent surface is directed downwards, we will evaporate a solution of sodium silicate, "water glass"—an operation it would be difficult to carry out satisfactorily by the ordinary means of heating the vessel by flame from below. By the new method, however, only the topmost layers of the liquid are heated—the radiant energy of the diaphragm is instantly transmitted to the surface of the liquid, where it is absorbed and utilized for the evaporation. The sodium silicate separates out as a skin on the surface of the liquid; it is then dried by the radiant heat; and at intervals the crust of dry sodium silicate may be skimmed off.

Incandescent Surface Combustion in a Bed of Refractory Granular Material.

The second process is applicable to all kinds of gaseous or vaporized fuels. It consists essentially in injecting, through a suitable orifice, at a speed greater than the velocity of back-firing, an explosive mixture of a gas (or vapour) and air, in their combining proportions, into a bed of incandescent granular refractory material which is disposed around, or in proximity to, the body to be heated.

It is obvious that this process is adaptable to many other furnace operations, as, for example, the heating of retorts, annealing furnaces, and the like. Moreover, it is not essential that the bed of refractory material shall be disposed around the vessel or chamber to be heated. It may be equally well packed into tubes, or the like, traversing the substance or medium to be heated. This latter modification is, as we shall see later, important in relation to the melting of metals or alloys which are fusible at temperatures below about 600° C., and also in relation to steam-raising in multitubular boilers. By this process much higher temperatures are attainable with a given gas than by the ordinary methods of flame combustion, without a regenerative system; and as a matter of fact, we have found that with any gas of high calorific intensity (such as coal gas, water gas, or natural gas) the upper practicable temperature limit is determined by the refractoriness of the material composing the chamber to be heated—*i.e.*, the muffle or crucible—rather than by the possibilities of the actual combustion itself. When I tell you that, in a crucible fired by coal gas on this system, we have melted a Seger-cone No. 39, which, according to the latest determination of your Reichsanstalt, melts at 1880° C., and also that we can easily melt platinum, you will appreciate the possibilities of the method in regard to high temperatures with gas-fired furnaces.

Indeed, at one stage of the investigation, we had considerable difficulty in obtaining materials for the construction of muffles and crucibles which would stand the high temperatures obtainable with coal gas; but we have now succeeded in constructing muffles which will withstand temperatures up to 1400° or 1500° C. It will also be obvious that the bed of incandescent granular material must be composed of a substance which will not at the working temperature exercise a fluxing action upon the walls of the crucible or muffle, or walls of the furnace.

As I have already stated, the method is applicable to all kinds of gaseous and vaporous fuels; but naturally the maximum temperature obtainable in any given case will depend upon the volume and heat capacity of the products for a given heat development in the bed. Thus, whilst with coal gas, water gas, or natural gas, it is possible to attain temperatures of up to at least 2000° C., with a producer gas of low calorific intensity, such as Mond gas, about 1500° C. would probably be the maximum temperature obtainable without regeneration. With some degree of heat recuperation, which in such a case would be quite practicable, in all probability this limit could be considerably exceeded.

Surface Combustion as Applied to Steam-Raising in Multitubular Boilers.

I now come to an important application of the process to the raising of steam in multitubular boilers, and to the melting of metals and alloys. I will first of all take the subject of steam-raising, and endeavour to explain the construction and performances of a new type of gas-fired boiler in which the principle of surface combustion is utilized.

It is well known that hitherto the gas firing of steam-boilers has not been very successful from the point of view either of thermal efficiency or of rate of evaporation. In Germany, you have a variety of gases available for steam-raising purposes—for example: (1) Blast-furnace gas, of which there is always a large surplus available from the blast-furnace plants; (2) the surplus gas which is obtained in the manufacture of coke in bye-product ovens; (3) "producer gas" of various compositions, but more particularly that manufactured under "ammonia recovery" conditions. All these gases have been found amenable to the system I am about to describe. It has been estimated by a prominent English blast-furnace engineer that the efficiency of the best type of water-tube boiler, fired by blast-furnace gas, does not exceed about 55 per cent.; and in the case of boilers fired by coke-oven gas, the average thermal efficiency of steam-raising probably does not exceed 65 per cent., though in exceptional cases it may amount to perhaps 70 per cent. But on applying the principle of surface combustion to the gas-firing of multitubular boilers, we have been able to obtain results corresponding to the transmission of nearly 95 per cent. of the energy represented by the net calorific value of the gas to the water in the boiler. I will now explain the construction and operation of such a boiler.

The ordinary multitubular boiler shown is of cylindrical section. It is traversed horizontally by a series of steel tubes, each one metre only in length and 7·5 cms. in internal diameter. These tubes are packed throughout their whole length with fragments of a suitable refractory material, meshed to a proper size. Into the front end of the tube, where the gaseous mixture is introduced, is fitted a fire-clay plug through which is bored a circular hole of about 2 cms. diameter. This plug serves a double purpose of keeping the front end of the boiler cool and of providing a suitable aperture through which the gaseous mixture may be introduced at a speed very much higher than that of back-firing.

Attached to the front plate of the boiler is a mixing chamber of special design. The mixture fed into the boiler-tube from this chamber consists of the combustible gas with a proportion of air very slightly in excess of that required for complete combustion. The mixture is injected or drawn in (either by pressure or by suction) through the orifice in the fire-clay plug, on to the incandescent material in the tube. The combustion of the mixture in contact with the incandescent material is completed before it has traversed a length of about 15 cms. from the point of entry to the tube. The result is that the core of the material at this part of the tube is maintained at a high temperature, though the *loci* of actual contact between the hotter material and the walls of the tube are so rapidly cooled by the transmission of heat to the water in the boiler that they never attain a temperature even approaching red-heat.

The combustion having been completed, the remainder of the material acts as a baffle towards the burnt gases as they traverse the tubes at a high velocity—causing them to impinge repeatedly on the walls of the tubes. The usual rate at which the gaseous mixture is fed into the boiler corresponds to an hourly consumption of about 3 cubic metres of coal gas, *plus* six times its volume of air for every tube of the boiler, or an equivalent volume (*i.e.*, equivalent as regards heating capacity) of any other gaseous mixture. Thus in the case of a ten-tube boiler, on which our original experiments were made, the consumption of coal gas was about 30 cubic metres per hour, *plus* about 170 or 180 cubic metres of air. This will convey an idea of the extremely rapid rate at which the mixture is caused to traverse the tubes.

After the burnt products have traversed the boiler tubes, and at their point of exit therefrom, it is found that their temperature is never more than about 70° C. above that of the water in the boiler, which, of course, depends upon the pressure at which the steam is being generated. This is a much lower temperature than that at which the products of combustion usually pass away from a multitubular boiler. But in order to still further increase the output of steam, the products are passed through a short tubular feed-water heater constructed on the same principle as the boiler. We have thus been able to reduce the temperature of the products leaving the feed-water heater to somewhat less than 100° C.

I will now briefly describe the construction and performance of a ten-tube boiler on which the original experiments at Leeds were carried out. The connections to the front of the boiler consist essentially of a tube for the supply of coal gas, and another for the supply of air. The gas and air are mixed before entering the feeding chamber, which is attached to the front plate of the boiler. The products pass outwards at the other end into a small chamber, and thence into the feed-water heater. The latter contains nine tubes, each 0·33 metre in length and 7·5 cms. in diameter, which are filled with granular material to effect the exchange of heat.

Results Obtained with the Boiler.

The mixture of gas and air was passed into the feed chamber of the boiler at a pressure of 44 cms. water-gauge. This pressure is necessary in order to overcome the resistance of the packing of the tubes to the passage of the gases through them. The pressure of the products entering the tubes of the feed-water heater was 5 cms. water-gauge, so that the pressure necessary to force the gas through the zone of combustion, and thereafter through the remainder of the length of the tubes of the boiler, was about 39 cms. water-gauge. When carrying out the test, the water was

evaporated at a pressure of 8·1 kilos. per sq. cm., and therefore at a temperature of 168° C. The temperature of the combustion products leaving the boiler tubes was 230° C. The average temperature of the products leaving the feed-water heater was 95° C. The temperature of the water entering the feed-water heater was 5·5° C.; and it was heated to 58° C. before entering the boiler, entirely at the expense of the burnt gases.

Let us now consider the heat-balance of the boiler during the test. The amount of coal gas fed into the boiler (expressed as dry gas at 0° C., and 760 mm.) was 28·20 cubic metres per hour. The net calorific value of the gas was 5001 K.C.U. per cubic metre; so that the total heat supplied to the boiler, in terms of the net calorific value of the gas, was 141,028 K.C.U. per hour.

As to the amount of water evaporated, the following figures apply to the combination of the boiler with its feed-water heater, because the two really comprise one steam-raising system. The temperature of the feed-water was 5·5° C., and the steam was being raised at a pressure of 8·1 kilos. per square cm. The actual amount of water evaporated was 204·2 kilos. per hour, which in terms of water evaporated from and at 100° C. would be 248·2 kilos. per hour. The actual heat, therefore, transmitted to the water was 133,014 K.C.U. per hour. The ratio between the heat transmitted to the water and the net heat of combustion of the gas burnt in the boiler, therefore, was 0·942.

It is one of the outstanding merits of the new system that we are able to burn the gas completely with a minimum excess of free oxygen; and during the test in question the average proportion of carbon dioxide in the combustion products was as much as 10·6 per cent., whilst the oxygen was as low as 1·6 per cent. The most careful examination of the products failed to reveal the presence of the slightest traces of CO, H_2, or CH_4. Therefore the remainder of the gas was simply nitrogen. Even with as little as 0·5 per cent. of oxygen in the products, the combustion of the gas in the tubes was perfect—not a trace of combustible gas escaping.

The Melting of Easily Fusible Metals and Alloys.

It will be readily understood that the principle embodied in the boiler is capable of great extension. Thus, for example: (1) The preliminary concentration of dilute solutions on the heating of liquids generally; (2) the heating of large volumes of air; and (3) the melting of easily fusible metals and alloys.

Unfortunately, time does not permit of my dealing with these further applications in every detail. I should like, however, to refer briefly to the results of experiments upon the fusion of lead and aluminium. The method is applicable generally to all metals or alloys whose fusion points lie below about 600° C. The diagram on the screen represents an iron tank, efficiently lagged, and filled to the top with molten lead at a temperature some 50°, or thereabouts, above its melting point. In the molten bath is fixed an iron tube about 0·7 metre in length and of 7·5 cms. internal diameter. This tube is packed (like one of the boiler tubes) with a suitable granular refractory material; and there are suitable arrangements for the introduction of the explosive mixture of gas and air which is to be burned in the tube. When once the device has been started up, it will work continuously for days together. Solid lead is continuously fed into the apparatus, and the molten metal is allowed to run over through the spout.

For the sake of simplicity, I have described and illustrated a small tank fitted with one combustion tube; but experiments have been carried out with tanks holding up to 8000 kilos, or more, of molten metal, in which a series of combustion tubes are fixed. By means of such an apparatus, lead (or other fusible metals or alloys) may be melted not only very rapidly but with extraordinary efficiency; and as an example of this, I will quote the results of a test carried out with a single-tube apparatus. These may be conveniently tabulated as follows:—

Lead Melting Test.

	C.
Temperature of metal charged	15°
,, ,, metal tapped	372°
,, ,, gases leaving apparatus	500°
Lead melted per hour	533·4 kilos.
Heat required per hour to raise metal from 15° C. to 372° C. = 533·4 × 18·14 = 9674 K.C.U.	
Gas burnt per hour	2·831 cubic metres

Net calorific value of gas = 4975 K.C.U. per cubic metre at N.T.P.

$$\text{Ratio} = \frac{9674}{14{,}084} = 0{\cdot}687$$

The conditions of the test were so arranged that the mean temperature of the molten metal in the apparatus throughout the test (as ascertained by a thermo-junction) was 372° C. Lead ingots, each weighing about 13·5 kilos, were added at intervals of 1½ minutes; and the molten metal displaced was simultaneously run off into moulds. Great care was taken to keep the bath thoroughly molten, and at a temperature within a few degrees of the mean value. Burning gas, of a net calorific value of 4975 K.C.U. per cubic metre, at the rate of 2·831 cubic metres per hour, it was found possible to raise the temperature of 533·4 kilos of lead per hour from 15° to 372° C.—the temperature of the products of combustion leaving the tube keeping constant at 500° C., or only 128° above the temperature of the molten metal. From the latest determination, by Spring, of the specific heat of lead at temperatures up to and above its melting point, and adopting the usually accepted value for the latent heat of fusion of lead, I calculate that the heat required to raise the temperature of 1 kilo of lead from 15° to 372° C. (including melting) is 18·14 K.C.U. Therefore the heat transmitted to the lead, per hour, during the experiment was 533·4 × 18·4 = 9674 K.C.U., whereas the net calorific value of the gas burnt per hour was 14,084 K.C.U. the ratio $\frac{9674}{14{,}084} = 0{\cdot}687$. Inasmuch, however, as the net heat of combustion of the gas is based on the assumption that the products of combustion (less steam) are cooled down to 15° C., whereas in the experiment the temperature of the molten metal was 372° C., it follows that the high ratio of 0·687 does not do full justice to the merits of the system. Under ideal conditions, the temperature of the gases leaving the combustion tube could not have been reduced below 372° C.; they were actually reduced to within 130° of this ideal temperature. Taking these circumstances into consideration, I calculate that the thermo-dynamic efficiency of the melting operations was practically 80 per cent. of that theoretically possible.

In similar experiments upon the melting of aluminium charged at 15° into the apparatus and tapped as molten metal at 765°, at the rate of 60 kilos. per hour, a thermo-dynamic efficiency of 55 per cent. has been attained—a result which I think may be somewhat improved upon when operating upon a larger scale.

[The diagrams referred to in the lecture are similar to those which have already appeared in the "Journal"—see April 11, 1911 (pp. 98-100; June 20, 1911 (pp. 914-918); Jan. 2, 1912 (pp. 27-28), and May 14, 1912 pp. 432-434.]

As already announced in the "Journal," Mr. Aneurin Williams will read a paper on "Co-Partnership" at the Royal Society of Arts to-morrow evening, under the presidency of Sir Corbet Woodall, D.Sc., M.Inst.C.E. On the 5th prox., Mr. Leon Gaster will deal with "The Economic and Hygienic Value of Good Illumination. Sir Arthur Whitelegge, K.C.B., M.D., the Chief Inspector of Factories, will preside.

We are told by the Clerk to the Chadwick Trustees (Mr. J. D. Richardson) that a series of free lectures will be delivered this year, under the Trust, in London and certain provincial towns. One of them will be on "Water Supply;" and it will be given at Birmingham by Mr. E. P. Hill, M.Inst.C.E. The object of the Trust, which was founded in 1895 under the will of the late Sir Edwin Chadwick, K.C.B., is the promotion of sanitary science in various ways indicated by the founder or otherwise at the discretion of the Trustees.

We learn from the Hon. Secretary of the Manchester and District Junior Gas Association (Mr. J. Alsop) that the third of the series of lectures arranged to be delivered in the Manchester University will be given by Mr. W. R. Herring, M.Inst.C.E., next Saturday afternoon, at three o'clock; the subject being "General Observations upon the Construction of Gas-Works and their Equipment." The chair will be taken by Mr. S. Meunier, of Stockport. After the lecture, Mr. W. L. Heald will read a paper entitled "Notes on Charging-Machines," which will be followed by a discussion.

"Gas for Everything for which Coal was formerly Used" is the attractive heading to a well spaced-out column advertisement of the British Commercial Gas Association in the Engineering Supplement to "The Times" on Wednesday last. In a series of short paragraphs, the writer enumerates a few points relating to gas and its use in the household, for shop, factory, and street lighting, heating, cooking, hot-water supply, manufacturing purposes, and power. The final paragraph contains the emphatic statement that "gas for everything for which coal has been used means a cleaner city for a healthier, happier people."

The discovery of a new gas has lately been announced by Sir J. J. Thompson, F.R.S., Director of the Cavendish Laboratories at Cambridge. It is claimed that the new substance holds the same relationship to hydrogen that ozone does to oxygen—*i.e.*, its chemical formula is H_3. Although Sir Joseph has been working on the subject for more than two months, he has only managed to obtain rather less than a cubic millimetre of the gas. He found this curious form of hydrogen hidden away in metals, especially iron, zinc, copper, and lead. Its properties are stated to be "as elusive as the sea serpent." It is not like ozone, for it is much less active than hydrogen. It will not explode when mixed with air or oxygen.

A Board of Examiners in connection with the fellowship examinations of the Society of Engineers having been formed, and the necessary rules and syllabus framed, the Council announce that arrangements are being made for holding the examination the second week of June next. Intending candidates should apply to the Secretary of the Society, Mr. A. S. E. Ackermann, B.Sc., at 17, Victoria Street, Westminster, for full particulars. The subjects will be divided into two groups—theoretical and practical; and the latter will include gas engineering and water supply. On the Board of Examiners are the following, whose names are quite familiar to "Journal" readers: Sir J. Fortescue Flannery, Bart., Messrs. J. Ferguson Bell, C. R. Darling, Percy Griffith, H. P. Maybury, H. O'Connor, F.R.S.Ed., E. H. Stevenson, E. Brough Taylor, W. A. Tookey, Arthur Valon, and W. Whitaker. Messrs. Griffith, Maybury, and Valon are upon the Executive Committee of the Board of Examiners.

LIQUID FUEL.

By Professor VIVIAN B. LEWES, F.I.C., F.C.S.

[The First of a Series of Cantor Lectures before the Royal Society of Arts on Jan. 20.]

I.

It is now more than twenty-six years ago that, in this room, I listened to a course of Cantor Lectures by Sir Boverton Redwood, on "Petroleum and its Products;" and so perfectly was the work done by that master of his art, that now, more than a quarter of a century later, all that is needed is to show the progress that petroleum has rendered possible.

What a record it constitutes! It has revolutionized transport and rendered aviation possible, it has given increase of speed and greater radius of action to our fleet, and in a hundred different ways has demonstrated its importance to a civilized nation; while even now we are on the fringe of still greater economies in power production by its use in the heavy-oil engine, so ably dealt with in Captain Riall Sankey's recent Howard Lectures, and by the latest developments in surface combustion.

EARLY APPLICATIONS OF PETROLEUM.

Twenty-six years ago by far the most important use to which any product of petroleum was applied was the creation of artificial illumination, while its utilization as a fuel was only beginning to attract general attention. The experiments that were being made in this direction usually resulted in the production of more smoke than efficiency, although Urquhart, Wise, Field and Aydon, and Nobel had already obtained good results. But had anyone then predicted the position to which it would attain in the first decade of this century, he would have been scouted as a mad dreamer.

By liquid fuel is meant liquids which, by their combination with the oxygen of the air, generate energy in such a form as to be easily utilized. For such liquids to have commercial value, they must be sufficiently plentiful to enable them to compete with solid fuel both in distribution and in price. While admitting the pre-eminent position occupied by petroleum products, we must not overlook the less favoured sources of power that are obtainable locally, and which in time of stress might be of great service should the more valuable, but less attainable, petroleum fuel supply be cut off. In all kinds of fuel we find that we are dealing with bodies formed by the absorption and rendering latent of energy during processes of vegetable or, more rarely, animal life, and that originally the energy has been derived directly or indirectly from the sun. When, by the process of combustion, we again resolve these bodies into the carbon dioxide and water vapour from which they were formed, the energy latent within them for perhaps geological ages re-appears as the sensible heat that we utilize for domestic comfort and conversion into the other forms of energy that we employ for light and power.

ORIGIN OF PETROLEUM.

The origin of petroleum is purely a matter of surmise, and many theories have been adduced from time to time to account for its formation. There is no doubt, as I pointed out long ago, that the primary rocks which form the basis of the world contain practically little or no carbon, and consist of fused and crystalline masses of silicates and other compounds produced at very high temperatures, and that where bitumen and hydrocarbons are found in lava and contained in pockets in outcrops of igneous rocks, they have got there by disturbance of carboniferous strata by the molten rock. It is a fair inference that the carbon which we now find present in the large class of sedimentary carbonates in the earth, and the carbon in coal, oil, and other carbonaceous material, have been derived from the carbon dioxide originally present in the prehistoric atmosphere. Everything, therefore, points to the early atmosphere of the world consisting of a mixture of nitrogen, carbon dioxide, and some oxygen. But it is clear that, even supposing the ratio of nitrogen to oxygen was not greatly different from that existing in the atmosphere of the present day, it must have been so diluted with the excess of carbon dioxide that, instead of there being 20·9 per cent. by volume of oxygen, there was probably only a fraction of this quantity; and under these conditions, decay, as we now understand the term, would have been almost unknown, and would have been much more akin to fermentation.

In a previous course of Cantor Lectures on the "Carbonization of Coal," I pointed out that this was the only really satisfactory explanation of the vast accumulations of vegetable matter needed to give the thicker seams of the coal formation, and that these actions, taking place during the carboniferous and tertiary periods, gradually absorbed the excess of carbon dioxide from the air and replaced it with oxygen—the factor of change being the growth of vegetation under the influence of the sun's rays. There is not the least doubt that it was during this same period of geological time (commencing perhaps even slightly earlier, and reaching its zenith in the tertiary age) that the formation of oil took place, or, at any rate, that the deposits of material accumulated, which afterwards, under conditions of pressure and terrestrial heat, gave oil as one of the products of their decomposition.

THEORIES OF THE FORMATION OF OIL.

The theory of the formation of oil which has been the one most favoured by the theoretical chemist has been that the oil is the product of the action of steam at high temperatures on metallic carbides, taking place probably at great depths; and that the hydrocarbon gases and oil have then found their way into, and collected in, the strata in which the oil is now found. Such brilliant chemists as Bethelot, Mendeleeff, and Moissan have all given their allegiance to this theory; the latter showing that the carbides of some of the rarer metals when acted upon by water yield hydrocarbons of much the same character as those found in the crude oil.

The first factor, however, which seems to cast doubt upon any such theory is that there are no signs of these vast deposits of carbides existing or ever having existed. To the practical man who has any knowledge of the oil fields, the evidence that at once disposes of this theory is that one may find a porous stratum of limestone or sandstone which is oil-bearing, while strata of identical character below it at a greater depth, and also above it, contain no trace of oil. So that it is evident that the oil has been formed in the strata in which it is found; and no theory which necessitates its formation elsewhere, and gradual infiltration into the strata, is admissible.

In the same way it has been suggested that petroleum has been produced by the heating of already formed deposits of shale, lignite, or coal, by the intrusion of igneous rocks. But in the oil-bearing measures themselves signs of such volcanic action are rarely to be found; and although one knows that such actions have given small quantities of oil in the coal seams, lignite, shale, or even peat deposits, it would be absurd to attempt to explain the vast volumes of oil formed in the large oil fields without being able at any rate to adduce proof of what has become of the residual carbon from the action, as, although lignite and even bituminous coals are found in many fields, they have evidently not undergone any such process of distillation. It may be taken as practically impossible that either of these theories can account for the production of the oil deposits.

All the evidence that can be collected goes to prove that the oil is of organic origin, and many observers have ascribed it to the checked decomposition over long periods of animal remains from the low forms of fish life. There are several points in favour of this, as undoubtedly brine and salt deposits are nearly always found in the oil fields, and in most cases with the oil itself, while fossilized deposits all point to a marine origin; and the work of Engler and Hofer shows that oil can be produced from such forms of animal matter. Practical considerations, however, make it perfectly clear that, even taking into account the differences between the atmospheric conditions then and now, which would affect not only terrestrial but marine growth, it is impossible to ascribe the origin of the vast quantities of petroleum occurring in Nature to any such source, although it is not only possible but extremely probable that some portions of certain oil supplies have been formed in this way.

The strata which constitute the storage for the oil are of a sedimentary character, consisting, as they do, of porous sandstone and limestone—both of them substances which might well have been formed from marine drift and deposits, while the limestone is known to consist largely of deposits either of substances like coral or the shells of myriads of minute forms of marine organisms; and I have always held the view that the real source from which the main bulk of oil has been derived was marine vegetation, which, under the conditions existing in those early days, probably grew in shallow seas in far greater quantities than are found at the present day. I am perfectly well aware that some authorities of wide experience are opposed to this view and hold it up to scorn; but all I have seen points to this being the real source to which we must look as the original matter from which the chief bulk of oil was formed.

Mr. Cunningham Craig, in his excellent book entitled "Oil Finding," published last autumn, devotes considerable space to proving the impossibility of oil having been formed from marine growths, and favours the theory that it is formed from the same sources as coal—*i.e.*, terrestrial vegetation—and that the conditions to which the vegetable matter has been subjected govern the nature of the product; so that with a deposit at a great depth closed in by an impervious stratum petroleum is formed, while the less loaded, or less perfectly sealed, horizons of a series yield coal. I am quite as ardent an advocate of the vegetable origin of most of the oil as Mr. Craig, and I admit that we know of coal seams in which springs of oil may be found, and oil fields in which seams of coal (generally tertiary) exist. But I think that Mr. Craig admirably sums up the chief objection to his theory when, in speaking of the similarity existing between the conditions under which coal and oil are found, he says: "In fact, the only difference is that in one case (coal) we have abundant evidence of vegetable

remains in under-clays, leaf beds, carbonaceous shales and sandstones, fossil tree trunks, and seams of lignite and coal, while in the oil-field phase not a trace of vegetable matter is observed."

In the body of true coal we find few traces of structure; and the resin constituents of the vegetable mass have luted the remains of the celluloses into coal. The lignites, however, formed from the vegetable debris collected at a later date, in many cases still show the original cellular structure; and we see that it is the fibrous portion which has best resisted destruction. In the formation of oil, however, no traces of fossilized remains, no traces of fibrous residue are left; and yet, as Mr. Craig clearly shows, in Trinidad one may find lignite and oil in different parts of the same sedimentary deposit—the oil being at the lower end of a sloping stratum, while the lignite is at a higher level. The forms of vegetation which contain no fibrous structure, and are therefore least able to resist structural destruction, are the true seaweeds; and these constitute the only form of vegetation that could conceivably be converted into oil and gases without leaving some trace of their origin.

The Seaweed Theory of Formation.

Imagine a low-lying shore, with its morasses and lagoons covered with dense vegetation and vegetable deposits which reach nearly to the storm-lashed strand, piled with marine flotsam and jetsam thrown up by the waves, and one can easily realize the possibility of change of level leading to both being covered by sedimentary deposits, and after the lapse of a few thousand centuries forming a stratum in which thin tertiary coal might be found at the end that was land, and traces of oil from the marine growths at the other. Any theory of this character, however, is worthless, unless the objections raised to it can be answered and evidence adduced as to its possibility; and Mr. Craig is not only a whole-hearted opponent to the theory, but formulates his objections with all the ability born of his long experience of the practical conditions existing in the oil fields. These may be summarized as follows:

1.—The initial difficulty of accounting for a sufficient quantity of raw material.
2.—When the water is removed from seaweed, of the remaining solids a "considerable proportion" is bromine and iodine salts, and if petroleum is formed from the remains of seaweeds, what becomes of the "enormous quantity" of these bromides and iodides?
3.—All petroleum contains a trace of sulphur and sometimes a good deal, "but there is no sulphur in seaweeds."

He concludes that "the chemical difficulties to be surmounted are therefore as insurmountable as the initial difficulty."

Mr. Craig, in reviewing the various theories of formation, lays it down that "the golden rule is never to postulate or suggest any condition or any mode of deposition or accumulation which cannot be shown or proved to be actually in operation at the present day." Such a rule would be good if all the factors that obtained in the past were the same as those existing at the present day. But when they are entirely different, as in this case, it can only lead to error. As an example, if this rule is to be followed, how would Mr. Craig explain the accumulation of vegetable matter needed to form some of the thick coal seams in various parts of the world, and which would require a dense decaying mass many square miles in area and some 300 feet thick? Grant, however, the differences in the character of the vegetation, the conditions in growth, the composition of the atmosphere, and earth temperature that must have existed in the carboniferous age, and the trouble disappears.

In the same way, the marine growths must have been of low order, growing luxuriantly in shallow seas of tepid water, immune from the ordinary forms of decay owing to the salt water being saturated with carbon dioxide and containing but little dissolved oxygen. But as they were cast on the strand in enormous quantities, being mixed with the sedimentary sand or shell, which, by subdivision, prevented the mass action found with terrestrial vegetation, they became, under the action of long ages and pressure, converted into oil, methane, and carbon dioxide. Even if the rule of applying modern conditions to the far distant past be adopted, is the quantity of weed produced as small as Mr. Craig imagines?

It is not so long since our own shores produced the kelp that was the source of alkali, of iodine, and of bromine, and fed a flourishing industry, until Le Blanc gave the world his soda process, and the Stassfurth mines and the Chilian deposits supplied potash salts, iodine, and bromine at a price with which the kelp process could not compete. In those days, seaweed was collected, not left a rejected gift on the shore, to be taken back by the incoming tide or used in small quantities as manure. The Hebrides alone yielded annually some 40,000 tons, Great Britain 200,000 tons, and the shores of Brittany double this quantity. Yet here we have not the conditions of temperature that favour such growths; and when one hears of the giant algæ of the Falkland Islands, with great fronds a quarter of a mile in length, and of weed being thrown up in the Straits of Magellan in such quantities that boats cannot get near the shore, one feels that certainly the imagination required to picture the huge deposits needful in the carboniferous and tertiary periods to give our oil fields is not greater than the call made upon it to supply terrestrial growths.

Turning to the chemical objections raised to the theory, we find again that the law that the present shall govern the past is responsible for part and error for the remainder. The first point is that if petroleum is formed from the remains of seaweed, what becomes of the bromides and iodides that constitute so large a part of these growths? It is perfectly clear that the substances found in seaweed or in any other form of vegetation have been absorbed by the plant, and vary according to their environment; so that although one finds bromides and iodides in the ash of marine plants at the present day, one finds none in plants grown in fresh or brackish water. The salts in solution in sea water are the result of generations of slow concentration, brought about by the supply of fresh water containing small quantities of salts in solution and evaporation; and over the geological ages which have elapsed since the carboniferous period, sea water has risen in density from 1 to 1·02, the amount of salt in solution has risen to 1850 grains per gallon, while the bromides and iodides, which are just as soluble as the salt, are, after thousands of centuries, only minute traces, which cannot be recognized without the concentration of large quantities of water.

It is extremely improbable, therefore, that in the carboniferous and tertiary periods any bromides and iodides were present in the water, and consequently would be absent in the weed. Moreover, if one takes the conditions of the present day, the weed which is richest in iodine is the tangle-wrack (*laminaria digitata*), the soluble ash of which contains less than ½ per cent. of iodine, while the commoner forms of seaweed, such as bladder-wrack (*fucus vesiculosus*), contain less than 1-10th per cent., so that the "considerable proportion" and "enormous quantities" to which Mr. Craig refers would not be so great, even judged by modern standards.

The fact also that every sample of petroleum contains some sulphur appears to Mr. Craig to be an insuperable objection, as he is under the impression that seaweed contains none. But, in point of fact, the carbonization of seaweed gives rise to very large quantities of sulphur compounds, as the mineral matter in the weed is very rich in sulphates, which reduction converts into sulphides. The result is that when kelp is moistened with water the smell of sulphuretted hydrogen is at once noticeable; while when lixiviated with hydrochloric acid, this gas is evolved in large quantities. That the reduction of the sulphates needed to bring this about is very small is clearly shown by the fact that on sub-tropical coasts where rivers bring down vegetable matter into the sea, sulphides are formed so freely from the calcium and magnesium sulphates in the sea water as to blacken the white paint used on a ship.

The Destructive Distillation of Seaweed.

So far, however, the evidence I have adduced with regard to marine growths being the source from which oil has been formed has all been to show that the objections raised to the theory by Mr. Craig are not of a very serious character; and it still remains to show that seaweed is the possible source. The utilization of seaweed for the production of various commercial commodities, as has been pointed out, led to a good deal of work being done upon it during the last century; and researches made by Mr. E. C. Stanford showed that when any kind of seaweed was submitted to destructive distillation at a low, red heat large volumes of gas were evolved and an oily tar was produced, which, on redistillation, yielded paraffin oil (as he termed it) in considerable quantities. From a ton of weed of the genus *fucus*, which is the most common marine growth, it is possible to obtain 6·7 gallons of oil; and this particular kind of weed contains the least iodine and the largest proportion of sulphates in its ash. The following table gives the figures for this weed:—

Fucus Vesiculosus (Bladder-Wrack).

	Per Cent.
Water	71·00
Organic matter	23·28
Ash—Soluble	4·10
Insoluble	1·62
	100·00

On Dry Weed.

	Per Cent.
Organic matter	80·358
Ash—Soluble	14·079
Insoluble	5·563
	100·000

Composition of Soluble Ash.

Sulphuric acid	4·165
Alkalies as chlorides	11·400
Iodine	0·00985

Per Ton of Dry Weed.

Volatile oil	354·5 oz.
Naphtha	220·8 ,,
Paraffin oil	515·4 ,,

In distilling the weed, a dull red heat was employed; and, in consequence, some compounds were formed having the same characteristics as those evolved from coal. But when distilling coal, the lower the temperature the more paraffinoid becomes the nature of the tar; and when the lowest possible temperature is employed, paraffins and naphthalenes of the kind found in crude petroleum are always present in considerable quantity. So that with a distillation such as has taken place in Nature, in which the material has been subjected to a comparatively low temperature

for an enormous period of time, one would expect that the character of the distillate would much resemble that of crude oil.

It is interesting also to note that peat, when subjected to destructive distillation under the same conditions of temperature as the marine weed, yields an oily tar, from which, by redistillation and purification, oil of the same character can be obtained, and also solid paraffin; but the quantity of the oil is rarely one-half that obtained from the weed. It cannot be insisted upon too strongly that, in the great natural processes of carbonization which have converted vegetable growths into coal and oil respectively, there have been countless ages of time and moderate temperatures taking the place of short periods of high temperature; and from everything we know of the nature of the changes induced in carbohydrates and hydrocarbons by heat, we should have expected the results that are found.

What Determines Coal Production and What Oil?

The broad question that remains is, Why in the one case should bodies of much the same character be converted into the solid conglomerate which we call coal, and, under other conditions differing but little, be converted into the mixture of liquids which we know as oil? As before pointed out, structure has probably a great deal to do with this. It must also be remembered that in marine silt the weed will be intermixed with sand or shell, and the mass action of a huge and uniform bulk of fermenting matter will be checked by subdivision, and the actions rendered slower than with terrestrial vegetation; while probably the most important cause of all is that in the land growths the extractive matter was of a highly resinous character, and, in an atmosphere of low oxygen content, protected the cellulose bodies and led to the formation of solid products of degradations and finally to carbon—these residues being luted together by the resin and such hydrocarbons as are formed into coal. With seaweed, resins are absent, and the extractive matter consists of jelly-like bodies offering no impediment to fermentation; so the action slowly proceeded until the whole mass was converted into gases and liquids.

Cellulose, which is the main constituent of all vegetable life, may be represented by the empirical formula ($C_6H_{10}O_5$); and we know that the gaseous products of its ordinary fermentation and checked decay are carbon, water, carbon dioxide, and methane. Under these conditions, the completed action has often been represented as—

$$2(C_6H_{10}O_5) = 6C + 3CH_4 + 3CO_2 + 4H_2O,$$

yielding the solid carbon found in coal; while under other conditions bathed in brine, the fibreless weed might undergo changes in which the formation of water was replaced by hydrogenation of the carbon

$$4(C_6H_{10}O_5) = 10CO_2 + 5CH_4 + C_9H_{20} \text{ (nonane).}$$

This is used only as an illustration, as it is an absurdity to represent a great natural action by an equation, when probably many different changes are taking place simultaneously. But it shows a possible decomposition which would yield one of the most important constituents of petroleum, and also natural gas—the carbon dioxide dissolving under pressure in the brine and being used up in such actions as forming soluble bicarbonates of calcium and magnesium—thus helping to dolomite the calcareous deposits.

Other Possible Sources.

This theory of the formation of oil from marine growths of the earlier period of the world's history fits in better with most of the facts observed in the oil-fields than any other; but it would be a great mistake to imagine all oil to have been formed from this source, as, under special conditions, undoubtedly oil is formed from local distillations of carbonaceous material, and also from animal remains. It is, however, safe to say that petroleum is a decomposition product of organic matter. Carbon differs from all other elements in that, instead of its combinations with other elements being of a simple character and occurring only in a few proportions, they are so abundant that their composition and properties form the largest portion of chemical literature, and that while oxygen—the most active in combination of the elementary bodies—forms only two compounds with hydrogen, carbon forms such a host that it is only by arranging them in groups according to the ratio existing between the hydrogen and the carbon atoms that we can systematize them.

By far the most important of these groups is the paraffin or saturated series, in which the ratio $C_n + H_{2n+2}$ is found in all the members, from methane (CH_4), the simplest member of the group, up to such bodies as ceryl ($C_{80}H_{62}$), all of which have been identified, as existing in Pennsylvanian petroleum, and the natural gas which accompanies it. The natural gas is chiefly methane, and the next three gaseous members of the group are also found associated with it; while from pentane, the fifth member of the group, up to about the fifteenth, the members are liquid, gradually getting denser and more viscid as the complexity of the molecule increases; and the higher members are solids dissolved in the lighter portions of the oil.

It is quite clear that in the decompositions taking place in the marine growths, with the organic matter subdivided by the sedimentary matter and in the presence of brine, the first actions will commence only slowly; and before any large amount of gas has been generated, the strata will have been sealed by superimposed deposits. In the formation of coal, on the other hand, the great fermenting mass of vegetation will be evolving gas far more rapidly; and long before the strata are sealed, the first stage of evolution will be completed. The proof that it is so is manifest in the pressures found in the oil strata and on cutting into a coal seam respectively. When oil is struck during drilling, pressures as high as 1000 lbs. on the square inch have been recorded; while in the "gasiest" coal mine the pressure is almost negligible.

It is also recognized among practical workers that the deeper and better sealed the oil strata are the greater will be the gas pressure, and the lighter will be the specific gravity of the oil and the richer in spirit—the only exceptions to this being in very sandy formations. So that it appears probable that the early creation of a high pressure has favoured the formation of light oils, possibly by causing the polymerization of the hydrocarbons that otherwise would have escaped as gases; while it is clear that it is also due to a certain extent to the impermeability of the seal preventing evaporation of the lighter portions.

It used to be supposed that petroleum contains no nitrogen; and as all fuels of organic origin contain a small percentage, this was looked upon as a strong indication of mineral oil being of inorganic origin. Mr. Beilby, however, showed that the presence of nitrogen in petroleum had been overlooked, owing to its concentration in the residuum left in the retort. It is now generally recognized that in most oil, although the quantity is less than with coal, its presence is fairly universal; while Mabery has shown that in Californian oil there is sometimes over 2 per cent. The same thing is found with oxygen, which is practically always present in small quantities in crude oil, and, on fractionating the oil, largely remains with the residual forming the pitchy matter left in the retort, although small traces of oxygenated compounds are sometimes found in the distillates.

To all intents, however, the substance we speak of as petroleum is a mixture of hydrocarbons having a specific gravity which varies from ·7 to 1·0 (either of which limits is but rarely reached), and capable of being separated by fractional distillation into a number of more simple mixtures. It has been shown that Pennsylvanian petroleum consists of a mixture of compounds containing many belonging to the saturated or paraffin series, represented by the ratio C_nH_{2n+2}. But the oil from the Baku district, in Russia, is found to contain a large proportion—some observers have put it as high as 80 per cent.—of hydrocarbons of different character, in which the ratio is C_nH_{2n}, but which do not belong to the ethylene series, which also consists of hydrocarbons in the same ratio. The same hydrocarbons are found in Californian oil. These hydrocarbons are now generally known as naphthenes, and are isomeric with the ethylenes; and many observers have conjectured that the differences in composition indicate a difference in source. It may be so. But the fact remains that by heating Pennsylvanian oil under proper conditions it can be converted into a mixture of naphthenes and other hydrocarbons of much the same composition as the Russian oil; and it seems more probable the differences mark various phases of formation rather than different sources, more especially as the two classes of oil may be found in fields not far apart.

Variations in Different Crude Oils.

It must always be remembered that the variations between the different crude oils, and still more between the fractions of medium boiling point, are remarkably small considering the variation of the conditions under which they have been formed, and which is due to the more complete elimination of the oxygen than is found in the conversion of vegetable matter into coal, where the protective action of the resins has prevented the full meed of decomposition of the oxygenated bodies. Take, as an instance, our great South Wales coalfield, with its variations from bituminous coal at the eastern end to steam coal in the central district and anthracites in the west. There can be no great difference in the age of the deposits; and yet ultimate analysis shows us that wide differences exist in the composition of the coal, and greater differences in their characteristics. If, now, the crude petroleums from all sources be analyzed, we find that oxygen exists only as a trace—that the reduction has been so thorough that only hydrocarbons of a limited number of series are left, and that as each member of a series, like the ethylene and naphthene groups, contains the same ratio of carbon and hydrogen atoms, each of them will have the same percentage composition; while in the paraffin series (C_nH_{2n+2}), the differences in their percentage composition will be due to a small proportion of the light hydrogen. So that the extreme variation which exists between the first member of the group; the gaseous methane, and the highest member found in petroleum, ceryl, is:—

	Methane (CH_4)	Ceryl ($C_{80}H_{62}$)
Carbon	75 per cent.	85·3 per cent.
Hydrogen	25 ,,	14·7 ,,

Supposing that the crude oils consisted of the paraffin series only, these percentages would represent the extreme variations. But inasmuch as the oils containing the saturated or paraffin series also contain still larger quantities of unsaturated hydrocarbons and small traces of oxygen, nitrogen, and sulphur compounds, the difference in their ultimate composition is far less; it more nearly approximates to that of the unsaturated series, as is shown by the table on p. 250, taken from Mr. A. Beeby Thompson's valuable work on "Petroleum Mining."

This uniformity in the composition of the crude oil, and the small variations found in the definite fractions obtained from it by distillation, are important factors in its use as liquid fuel, as instead of being obliged to select the source of the supply and

Ultimate Composition of Representative Petroleums.

Origin of Petroleum.	Specific Gravity.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.
Pennsylvania	0·801	86·10	13·90	..	..	0·06
Ohio	0·827	83·42	14·59	0·064	..	..
California—heavy	0·984	86·32	11·70	1 25	..	0·84
light	0·846	86·24	13·08	..	..	..
Texas, Beaumont	0·912	85·03	12·30	..	0·92	1·75
Roumania, Bushtenari	..	86·30	13·32	..	..	0·18
Compina	..	86·03	13·26	..	..	0·13
Canada, Petrolia	..	83·94	13·37	..	..	0·99
Peru, Zorritos	0·850	86·08	13·06	0·071	0·748	0·04
Italy, Parma	0·786	84·00	13·40	..	1 80	..
Russia, Baku	0·884	86·3	13·6	..	0·1	..
Galicia	0·852	85·3	12·6	..	2·1	..
Burma	0·855	83·8	12·7	..	3·5	..
East Indies, Java	0·880	87·1	12·0	..	0·9	..

character of the material, as is the case with coal, we know that, given a satisfactory flash point, viscosity, and sulphur content, we shall obtain fairly uniform results, whether we are dealing with an American residuum or a Russian Ostatki.

There was a time when the occurrence of petroleum was supposed to be restricted to a very few favoured localities. This period is long past; and it is now recognized that very few countries exist in which small quantities are not to be found—even England being fluttered during the past year by a deep boring near Newark yielding some few gallons, while traces have been found as near London as Willesden. It by no means follows, however, that there exist many fields of the prolific character of those in the Baku or Pennsylvanian districts, which during some forty years yielded the bulk of the world's supply, and which are now pointing the moral that an oil field, however prolific, is only a natural storage tank for a long dead manufacture, and that the more fields we develop and the more petroleum we use, the nearer are we getting to the inevitable end of the supply.

The world's output of petroleum is now nearing 50 million tons per annum, of which during last year we imported into the United Kingdom something like 1,250,000 tons of products, 70 per cent. of which came from America, while the Dutch East Indies, Roumania, and Russia, in the order named, made up the bulk of the remainder.

Perhaps the best idea of the importance of the world's oil fields may be obtained from the following table, in which the percentage of total oil produced is given:—

United States	63·99	Mexico	1·02
Russia	21·48	Japan	0·59
Galicia	3·87	Peru	0·40
Dutch East Indies	3·37	Germany	0·32
Roumania	2·97	Canada	0·10
India	1·87	Other sources	0·02

PRODUCTION OF BENZOL.

This was the subject of an article in a recent Engineering Supplement to "The Times."

The writer begins by mentioning that, soon after Perkin made his discovery of the aniline dyes, the demand for benzol became so great that its price touched 15s. a gallon; whereas it could be obtained five years ago at 6d., or even less, though it has now risen to 11d. Long before it reached its lowest price, it had been recognized that it could be used instead of petrol in internal combustion engines; and in the few large gas-works which distilled their own tar the spirit was often utilized for motor-car purposes. The results, so far as power went, were distinctly better than those obtained with petrol; the increase generally being from 10 to 12 per cent. In the United Kingdom there are upwards of 1600 gas-works; but it is only the largest of these—probably amounting to not more than 2 per cent. of the number—which distil their tar in such a way as to recover the benzol. It is therefore only in certain centres that it can be obtained as a product of gas manufacture; and inasmuch as 10 tons of coal are required to yield a gallon of benzol, it is clear that the supply would not stand a very large demand.

It is pointed out that the coal carbonized in the gas-works of this country may be taken at 15 million tons annually. Hence, if all the benzol were recovered from the tar, the yield would be 1½ million gallons, while 20 million tons of coal in the coke-ovens would give 60 million gallons. The fallacy, however, of supposing that this benzol could be rendered available as motor spirit is, the writer says, found in the fact that probably not more than 5 per cent. of the coal used in gas-works has the tar so treated as to yield benzol, and the total amount of benzol and toluol from the gas industry does not amount to 50,000 gallons per annum. Considerably less than half the coal which is converted into metallurgical coke is treated in recovery plant—only 81 out of a total of 224 coking works recovering bye-products; so that the total production of benzol is but a very small proportion of the possible amount.

Passing on to consider the reasons for this apparent disregard of the possibility of recovering so valuable a bye-product as benzol, the writer says:

In the gas industry the chief factor is that it is only in the largest works that sufficient tar is produced to keep distillation plant running continuously; and unless this can be done, it is more profitable simply to boil off the water and light oils, and utilize the residue for road making, which for this purpose finds a ready market all over the country. Now, however, that Parliament has declined to interfere in the inter-trading between gas companies in their residuals—a restriction which the chemical manufacturers and tar distillers sought to have imposed—it is to be hoped that the smaller gas-works throughout the country will combine in a districting arrangement by which in a given area central works may put up the necessary plant to distil off and recover the benzol from the tar in that district. By selling the prepared residue to the local authorities for road work, they would obtain a far better price for their tar than could possibly be given by a tar distiller, who would have had to pay carriage to the distillery, perhaps at a considerable distance, and then probably bring the prepared tar back to the very district from which he had obtained the raw material.

From what has been said, the writer thinks it is clear that, in existing circumstances, it is useless to look to benzol as being more than an auxiliary to the petrol supply. He is of opinion, however, that in the future the price of motor spirit may reach a point that will "force the gas industry to break away from the trammels of past practice and to adopt low-temperature carbonization, by which the volume of tar produced could be doubled, and the volume of distillate available as motor spirit from it so increased that it would become an important factor in supplying the shortage in petrol that must begin to show itself before another fifty years have passed."

TIME ALLOWED FOR THE SETTING OF CONCRETE

A question on this subject having been sent to the American "Gas Institute News," the following answer was given by the Bureau of Information of the Institute.

It is not possible to answer this question positively and definitely, since the ability of recently laid concrete to sustain a weight depends very much upon circumstances and conditions. It does make a difference whether the concrete was put down in cold, moderate, or hot weather, since in the first instance it will set much more quickly than in the last. It also makes a difference whether just sufficient water or an abnormal quantity has been used in mixing, and whether the concrete bed has been protected against the influx of water or whether it has been more or less inundated. An excess of water will always retard setting.

As to placing weight upon the concrete, it should be known whether the whole load for which the foundation was calculated is to be put on at once, or whether it will go on gradually, as in the case of a brick wall, where the superimposed weight grows slowly and evenly. Cements and concretes gain in tensile as well as in crushing strength within certain time limits. Different brands of cement vary as to this gain. Some reach in (say) seven days a strength which is fully 60 per cent. of that obtained in 60 days, where others show only 30 per cent. of final for such initial strength under the same conditions. Mr. Knapp, in his paper read before the American Gas Association ten years ago, mentioned a case where loaded teams were driven over concrete beds only 24 hours old without doing harm. But tip-top conditions must have obtained in that instance to make this result possible.

In the case of the building of a brick or stone wall upon a concrete base, it would be safe to commence the work as soon as the surface of the base has hardened sufficiently to resist scratching it with a nail—a condition which would ordinarily be reached in a couple of days. In the instance of a thick concrete bed which is to carry heavy machinery, one, two, or more weeks should elapse before the weight is put on—the length of time depending upon the quality of cement used and on other conditions stated above.

The Humphrey Pumps at the Chingford Reservoir.—In connection with the paper submitted to the London and Southern District Junior Gas Association last Friday, and given in another part of the "JOURNAL," it may be mentioned that the first of the five large Humphrey pumps which the Chief Engineer to the Metropolitan Water Board (Mr. W. B. Bryan, M.Inst.C.E.) has installed to feed the new reservoir at Chingford was started-up on the 19th inst. with complete success. It is stated that the pump, which was rated at 40 million gallons per day, is very considerably exceeding this output; the discharge being at the rate of fully 50 million gallons per day. It works extremely quietly, and with very little vibration. The combustion chamber is 7 feet in diameter, and the number of cycles nine per minute.

Recent Research on the Gas-Engine.—It has already been announced that Professor Bertram Hopkinson, F.R.S., of Cambridge, would deliver two lectures on the subject of gas-engines at the Royal Institution, Albemarle Street, W. The first will be given next Thursday afternoon, when the lecturer will deal with the practical difficulties occurring in the design and operation of large gas-engines: The problem of cooling; pre-ignition; recent researches on heat-flow in closed vessels and in the gas-engine cylinder; radiation from hot gas; and the effect of the density, volume, and temperature of the gas on heat-flow. In the second lecture, Professor Hopkinson will consider the effect of turbulent motion of the gas on heat-flow; the relation between the efficiency and the speed of an engine; measurement of turbulence in the gas-engine; experiments on the effect of turbulence in closed-vessel explosions; and turbulence and the velocity of ignition.

MEASUREMENT OF LIGHT AND ILLUMINATION.

The first six of the course of lectures on illuminating engineering being delivered at the Regent Street Polytechnic, took place before Christmas. The subject was "Modern Illuminants." The first lecture in the New Year, by Dr. Ettles, on Jan. 17, dealt with "Illumination and the Eye;" and last Friday Mr. J. S. Dow gave the first of the final five lectures, devoted mainly to practical applications.

The subject for the evening was the measurement of light and illumination. The lecturer commenced with a reference to the events of the past year. Even in this short period quite a number of developments in photometric apparatus had taken place. Particular mention was made of the display at the Optical Convention held last June. On this occasion a special section was devoted to illuminating engineering; and a number of firms, both gas and electric, exhibited side by side various forms of shades and reflectors, and showed how readily measurements of light and illumination could be applied to demonstrate their advantages. In fact, measurements of this kind have become of industrial importance.

Proceeding, Mr. Dow explained what was meant by the term "candle power" or "intensity." The method of testing the candle power of lamps merely compared their power of creating brightness. This is the main point for purposes of illumination. There are, of course, other qualities (penetrating power, actinic value, &c.) of an illuminant which are sometimes important; but these really require special tests. It would be observed, therefore, that in judging the effect of illuminants one ought to examine the room, or the surrounding objects illuminated by them, rather than the lamps themselves. People were sometimes inclined to judge lamps by their apparent brightness; but this was a mistake. Such judgments were based more on intrinsic brilliancy—*i.e.*, candle power per square inch of radiating surface—than anything else. High intrinsic brilliancy was a factor which one usually desired to avoid in practice, as it caused an installation to give the impression of glare.

Some slides were thrown on the screen illustrating the cosine and inverse square laws, as used in photometry, and there was also exhibited a simple model (borrowed from the Holophane Laboratory) showing these laws. A picture of the bench used at the National Physical Laboratory was next shown, and the ordinary process of comparing lamps briefly described. Passing on to standards, Mr. Dow explained how the old standard candle had been replaced by more permanent and trustworthy standards, though the term "candle power" was still used, and the value of this unit was, for practical purpose, not far removed from the intensity of the candle. A great simplification had been made by the agreement between Great Britain, France, and the United States to use the same unit, equivalent to 1·10th the light given by the Harcourt pentane standard, and now termed the "international candle." Germany used a different unit—the Hefner = 0·9 international candle; but the relation connecting the units was a simple one, so that values could easily be converted.

The lecturer then passed on to the chief terms used in illuminating engineering, showing how the unit of illumination, the foot-candle, was derived. On the Continent, the "lux," or the metre-candle, was used. The lux is approximately equal to 1·11th of a foot-candle. A unit that was now being introduced into lighting calculations in England was the "lumen," which might be defined as the quantity of light required to illuminate one square foot with an intensity of one foot-candle. It was sometimes useful in dealing with large illuminated areas. As an illustration of its employment, Mr. Dow made a calculation showing that theoretically, if all the light produced in the lantern could be used scientifically for the purpose intended, only about 5-candle power should be necessary to give the required illumination on the screen. Yet, as a matter of fact, it was necessary to use a lamp giving several hundred candle power at least, because so much of the light was wasted.

The next point dealt with was the distribution of light from illuminants. It was pointed out that many lamps gave their maximum light in a horizontal direction, whereas the greatest illumination was usually desired underneath the lamp. A slide was shown illustrating the distribution of light from carbon and metallic filament electric lamps, upright and inverted gas-mantles, mercury vapour lamps, &c. In each case, quite a different polar curve of light-distribution was obtained. When speaking of the candle power of such lamps, it would usually be found that the candle power in the maximum direction was given. In most cases when the "cost per 1000 candle-power-hours" of an illuminant was stated, this question of the distribution of light was not taken into account. Yet it was obviously not a proper method merely to give the intensity of the maximum ray, especially when the lamp was provided with a reflector concentrating most of the light in one particular direction. An extreme case of such concentration would be a searchlight or a motor-lamp.

Clearly a lamp that gave a certain value in one direction only ought not to be rated in the same way as one that gave this light over the whole lower hemisphere. We are rapidly approaching a time when, by the use of suitable reflectors, we shall be able to give any lamp any desired distribution of light—*e.g.*, we can arrange to concentrate nearly all the light downwards, to throw the light on the ceiling, or to direct it sideways so as to illuminate a notice, book-shelf, placard, &c. Therefore it would seem that the most satisfactory method of comparing lamps (as distinct from the shades or reflectors used with them) was to state either the total flux of light or the average of the rays in all directions.

This led to an explanation of some methods of determining polar curves of light distribution; and the lecturer referred to the method, now becoming usual, of denoting exactly what was meant by speaking of the "candle power of a lamp by the use of special nomenclature (I_0 for mean spherical candle power, $I_{\cap}$ for mean upper hemispherical, and $I_{\cup}$ for mean lower hemispherical candle power). The action of the Ulbricht globe and the Matthews integrating mirror photometer was explained by the aid of slides and diagrams. The Ulbricht globe had been largely used on the Continent; but, in the lecturer's opinion, it seemed questionable whether it could be applied to units which concentrated the light almost entirely in one direction. There was also a difficulty in using it with gas-lamps, seeing that enclosure in a confined space and lack of free access of air to the lamp were very apt to affect the light.

The concluding portion of the lecture was devoted to measurements of illumination. Mr. Dow explained how, during the last few years, a demand had sprung up for simple and portable instruments, such as could be used to measure the illumination at the actual spot where the light was needed—*i.e.*, on a desk in a schoolroom, or at the bench in the factory, &c. Naturally, in order to get extreme convenience and simplicity, some sacrifice as regards accuracy was necessary; otherwise one would obtain something in the nature of a travelling photometer-room rather than an illumination photometer. But an accuracy of 5 or 10 per cent. was probably enough for most practical purposes.

A number of instruments of this kind were exhibited and described, including the Holophane "Lumeter," the "Lightometer," and the "Luxometer." The lecturer commented on the variety of apparatus of this kind that had been introduced since he had been led to devise the Holophane Lumeter, in conjunction with Mr. Mackinney, about two years ago. As an illustration of the use of such instruments, some data—obtained in schools, libraries, and railway stations—were presented, and special mention was made of the complete series of measurements, over 2500 in more than a hundred different factories, recently undertaken for the Home Office by Mr. D. R. Wilson.

After an expression of thanks to those who had exhibited apparatus, the lecturer announced that next Friday he would deal with shades and reflectors.

South-West of England Association of Gas Engineers.

The annual meeting of this Association was held at the Royal Ashton Hotel, Taunton, last Friday—Mr. J. Armstrong, of Ilfracombe, the President, in the chair. The resignation of the Hon. Secretary (Mr. A. S. Brook), who has left the district on being appointed Gas Engineer and Manager to the Lisburn Urban District Council, was accepted, and a vote of thanks to him was unanimously passed for the able manner in which he had discharged the duties of the office since the inauguration of the Association. Mr. Brook was not present; but he is to be asked to accept an illuminated address and a fruit-stand, subscribed for by the members, as a slight recognition of the work done by him. Their best wishes were expressed for his success in his new sphere. The officers for the ensuing year were elected as follows: President, Mr. P. Thomas (Wellington); Vice-President, Mr. W. L. Copp (Axminster); Hon. Auditor, Mr. J. H. Cornish (Bridgwater); Hon. Secretary, Mr. H. D. Lumb (Chard). The Council consists of the President, Vice-President, and Hon. Secretary, with the Past-President (Mr. Armstrong) and Mr. Clark Jeffery, of Tiverton.

Gaslight as a Preserver of Foliage.

A recent number of "La Nature" contained a specially interesting photographic view of a portion of the Boulevard Raspail, in Paris, where, as readers may remember, there is an installation of high-pressure gas lighting. It was found last month that the young trees on the boulevard had, as usual at this time of year, lost their leaves, but, curiously enough, not from the branches extending towards the high-pressure gas-burners, which are shown to be still in position. As bearing to a certain extent on this subject, it may be mentioned that in "Competition Points for Gas Salesmen" (p. 103) reference is made to some experiments carried out by Mr. L. C. Corbett with the object of ascertaining the effect of direct gas lighting on vegetable growth. He used eight Welsbach burners uniformly distributed for lighting and a large number of plants. Those grown in this artificial light were larger, heavier, and finer, and grew more rapidly, than those grown at the same time in ordinary conditions. The experiments referred to, as pointed out in the work mentioned above, raise the question whether gaslight does not cause the chlorophyll cells to decompose carbonic acid and form fresh cells just as sunlight does. At all events, it would seem that powerful incandescent gaslight has a preservative action on foliage.

The late Sir Thomas Skewes-Cox, a Director of the Richmond and Hampton Court Gas Companies, whose death was announced in the "JOURNAL" for the 19th of November last, left estate of the gross value of £5050.

THE HUMPHREY PUMP.

By H. de P. Birkett, B.Sc.

[A Paper read before the London and Southern District Junior Gas Association, Jan. 24.]

The application of the internal combustion principle, with its inherent economies, has within the memory of all of us shown an extension that can only be described as phenomenal. But all the activities of the mechanical engineer in this direction were only rendered possible through the accumulated knowledge and experience of the gas engineer. With gas "on tap," practically unlimited in quantity and uniform in quality, the pioneers of gas-engine construction were free to devote their attention to the perfecting of the machine itself. This done, the astonishing departures in the direction of gas-engine, oil-engine, petrol-engine, the Diesel engine, and also in producer gas plant are to be regarded as merely in the nature of a "legitimate inference." Bearing in mind, then, that the gas engineer is responsible for the favourable environment in which the explosion engine commenced its evolutionary and revolutionary career, it is only in the nature of things that there should be introduced to an association of gas engineers the very latest fledgling of the internal combustion brood.

The Four-Stroke Cycle Pump.

Mr. H. A. Humphrey, the inventor of the Humphrey pump, has told elsewhere how it came about that his attention was drawn to the problem of the internal combustion pump. Personally, I think the Humphrey pump was invented because the world needed it; and I have very good grounds for my belief. Most of you here have had experience of running machinery, and while all can admire the workmanship and the material which result in a machine of almost superhuman reliability, there is no one who would not dispense with as many moving parts as possible. It is here that the Humphrey pump makes what is perhaps its strongest appeal. The simplest type of four-stroke cycle pump shown in the first illustration consists of a pipe P connected by a bend to the combustion chamber C at one end, and at the other terminating in an expanding cone pipe or water-tower T, reaching to the level to which the water is to be pumped. In this system the water is free to surge backwards and forwards—free, that is, as far as any mechanical device is concerned; and the function of the conical water-tower is to convert into pressure energy the kinetic energy imparted to the water-column by the explosions, and so to give a continuous flow of water from the system to the higher level through the outlet O.

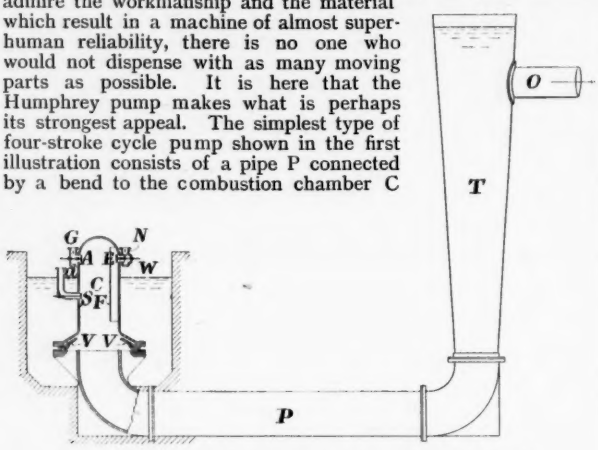


Fig 1.—The Humphrey Four-Cycle Drowned Suction Pump.

The Cycle of Working.

The cycle of working of the pump is now very probably familiar to most of you; but as it is thoroughly representative of the principle, and is actually the type installed in the case of the largest plant yet undertaken in practice, it may be worth while to recapitulate. Suppose the system to be full of water as shown, and a charge of explosive mixture to be in the upper part of the combustion chamber C. The admission valve A, exhaust valve E, scavenging air valve S, and water inlet valves, are all on their seats when ignition occurs. The expanding gases drive the water column before them down the combustion chamber along the "play" pipe P and up into the water-tower. When the pressure of the gases in C has fallen to about that of the atmosphere, the exhaust valve E opens automatically. There is now no force acting on the end of the water column; but the momentum imparted to it carries it further forward, tending to cause a partial vacuum in C. A non-return valve N prevents exhaust gases being drawn back from the exhaust pipe, and a few inches of vacuum is actually formed, causing the scavenging air valve S to be drawn open and assisting the head of water above the valves V to open them. The incoming water mostly mingles with the still outwardly moving column; but part of it rises in C to about the level W, partially exhausting the products of combustion.

Soon the energy of the column is expended, the water-valves V quietly close, and the column comes to rest, but only for an instant, for we have a state of unstable equilibrium—the apple is detached from the tree, and it must fall though the greatest philosopher of the ages meditates beneath. We have the water level in one leg of our U tube at a higher level than in the other, and atmospheric pressure at either end; so the water column starts to flow inwards, driving out the rest of the products of combustion and gaining kinetic energy until it reaches the open exhaust valve E, and shuts it. A small cushion of products diluted with scavenging air is thus trapped above the level of the exhaust valve, and the energy of the returning column is transformed into pressure energy by compressing this cushion to a pressure greater than the static head which caused the return flow. The cushion expands again, giving the second outstroke, and again the momentum of the column carries the level in C so low that there is a partial vacuum; but this time the exhaust valve E is locked, and the valve A unlocked, and a fresh charge of gas and air is drawn into the chamber. A second instroke of the water column compresses the charge, which is fired, and the cycle is repeated.

A close description of the cycle is necessarily somewhat lengthy; and it must be remembered that many of the operations described take place simultaneously. The point I wished more particularly to make, however, is that all the functions of the various valves (which are the only moving parts) are performed automatically, and the movements take place under the influence of very slight differences of pressure. Later on, one of the devices for locking the admission and the exhaust valves alternately will be described, and also the ignition apparatus used. But before leaving the description of the first illustration, attention should be drawn to the baffle (F). This takes the form of a light metal sheet bent to semi-circular section and attached vertically to the inner wall of the combustion chamber, so that it envelopes the exhaust valve. It is open at the top and bottom, and is carried down so that the lower end is always immersed. The object of this device is to obtain a larger measure of air in the cushion, with the result that the incoming charge is less contaminated by the burnt gases remaining in what is more or less equivalent to the clearance space of a gas-engine.

Scavenging air is admitted, as will be seen, relatively low down in the combustion chamber, and, being heavier than the hot gases, tends to remain below them. When the water column returns on the cushion stroke, the exhaust gases are driven out from the top of the chamber downwards through the top opening of the baffle, and, apart from diffusion, the cushion might be expected to contain little else than pure air. This effect is more clearly shown in the two-stroke cycle diagrams, figs. 2 to 6. They illustrate in section the combustion chamber only; and here the baffle used takes the form of a vertical partition down the centre of the combustion chamber.

As before, we have a compressd charge in the top of the combustion chamber. This is ignited and expands, driving the water column before it until the pressure reaches that of the atmosphere. It is arranged that at this moment the admission valve and the surface of the water shall more or less coincide, and, as the column moves on, the exhaust and admission valves are sucked open, admitting a fresh charge into the lower part of the left-hand side. The admission valve closes, and the column commences to return, driving out burnt gases from the right-hand side and from the top of the chamber until it reaches, and closes, the exhaust valve, trapping the fresh charge in the top of the chamber. The further upward movement compresses the charge ready for a fresh cycle. The rate of diffusion between the incoming charge and the burnt gases is quite incalculable, and varies widely under different circumstances. Hitherto no two-stroke cycle Humphrey pump, which draws in its combustible charge, has given such economical results as have the four-stroke cycle types. I shall therefore confine my remarks mostly to the latter.

Returning to fig. 1, a very useful function is performed by the baffle F, apart from the legitimate duty of guiding the flow of exhaust gases. If we introduce into it a small throttle valve, we can at will retard the upward flow of water within the baffle, and thus cause the exhaust valve to close later or earlier as may be desired. The Humphrey pump has an astonishing flexibility in working against variable heads; and with the aid of this simple device we have a means of adjusting the cushion volumes and the pressure to the best possible condition for any particular lift.

The Four-Cycle Suction Pump.

The next illustration (fig. 7) is a section of a type of pump which, though known as the Humphrey suction pump, is similar in most respects to the simple drowned suction type, and part of the total lift is arranged to be fitted on the delivery side, so as to give the return energy as before. As regards external conditions and appearance, the salient points of difference are that the pump can be placed above the level of the suction water, which is drawn up into the pump through the suction pipe J, and, secondly, that now the water-valves V must necessarily be surrounded by a closed tank K. This tank acts also as an air-vessel, and gives a more or less constant flow in the pipe J.

As regards the interior economy of the pump, there is no difference; but there is this important difference in the working of the cycle—namely, that on the working stroke the ignited gases

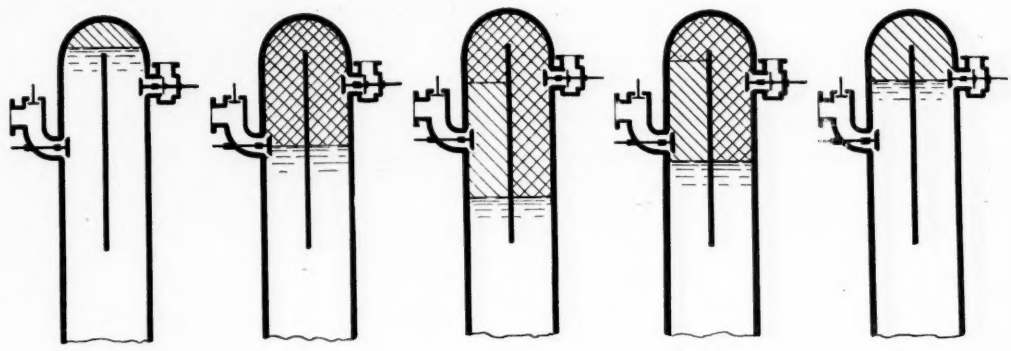


Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6.

TWO-STROKE CYCLE DIAGRAMS.

must be expanded down to the degree of vacuum equivalent to the amount of suction lift. There is therefore no partial exhaust. In practice, however, the cooling of the burned gases raises the level of the water in the combustion chamber, while the outwardly moving column is drawing fresh water into the pump, and a considerable amount of scavenging air is drawn in through the automatic valve S. This valve is held closed by a spring, and the tension is set so that the valve only opens when the absolute pressure in the combustion chamber is lower than that equivalent to the suction lift. Before the inertia of the incoming

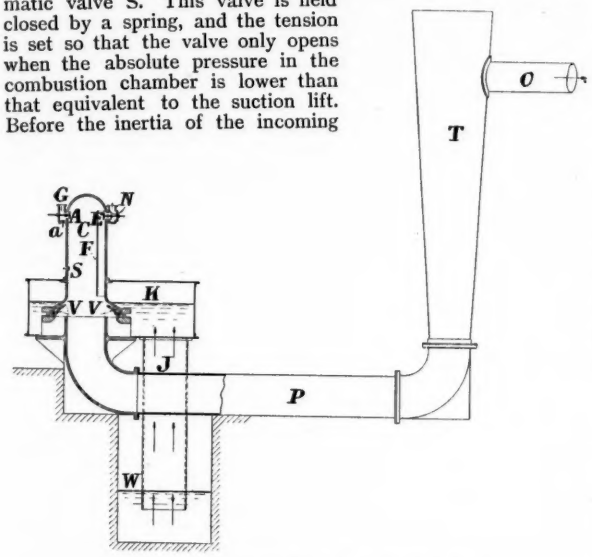


Fig. 7.—The Humphrey Four-Cycle Suction Pump.

water is overcome, the pressure inside falls considerably below this point, and scavenging air enters before the water—to dilute the exhaust gases and still further cool and contract them.

The flexibility of the pump when at work is such that, without adjustment and without appreciable difference in the cycle, it can deal with suction lifts varying from zero to 8 or 10 feet. A pump of this type is now under construction for the South Willesborough Sewage-Works of the East Ashford Rural District Council, in Kent, and a larger pump was recently sent to South Africa for irrigation work. There are also six pumps of this type under construction for sewage work in India.

Valves and Gear.

The gear which locks the admission and exhaust valves alternately is next illustrated (fig. 8); and this shows also a typical arrangement of admission and exhaust valves. On the left, in horizontal section, and on the right, in elevation, part of the combustion chamber C is shown carrying horizontally the admission valve A and the exhaust valve E. The admission valve carries on its stem the gas-valve G, which leaves its seat just after the main valve A begins to open, and closes just before it. On the admission stroke, gas enters the valve bonnet through the port G^1, and, flowing along the central portion, mixes with air just as it passes the valve; the air being drawn in by way of the annular part of the valve bonnet. A throttle on the air inlet port A regulates the richness of the mixture. It will be seen that the double valve is normally held on its seat by a light spring, against which it is sucked open when the pressure inside the combustion chamber falls below atmospheric pressure on the admission stroke.

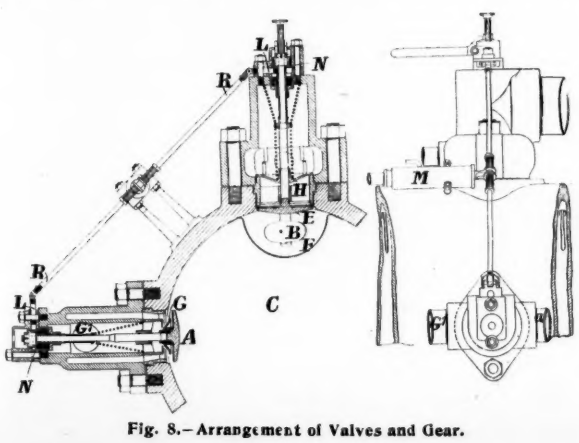


Fig. 8.—Arrangement of Valves and Gear.

The exhaust valve E is quite similar, but carries, instead of a gas-valve, a light non-return valve N. The exhaust valve is normally held open by the light spring shown, until the rising water reaches and shuts it. Surrounding the valve is the baffle F. The functions of this and the small throttle valve B have already been explained. On every alternate stroke, each of these two valves must be locked and unlocked. This is accomplished in a simple manner by locking bolts L sliding under nuts N on the valve stems. The locking bolts are connected by links to either end of the rod R, which is oscillated by the operating mechanism shown in elevation at M and illustrated in detail. It should be borne in mind, in studying this diagram, that the apparatus is quite small—a 1-inch bore size being sufficient for almost the largest pumps.

In the cylinder (1), the piston (2) works freely; the "fit" being obtained by the cup leather (5). In the left-hand section, the piston is shown at its highest position, having been forced up by the pressure in the combustion chamber, to which the lower end of the mechanism is connected by means of a pipe. Let us suppose that this rise of pressure was due to the ignition of a charge on the working stroke of the pump; all valves being upon their seats. The dagger (7) has forced the rocker (9) to the right, and this, in turn, has actuated the locking rod and bolts shown in fig. 8, so that the exhaust valve is unlocked and the admission valve is locked.

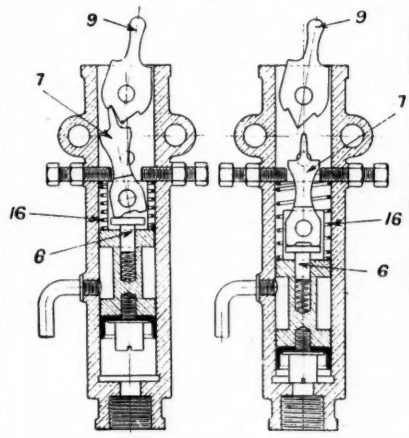


Fig. 9.—Operating Mechanism.

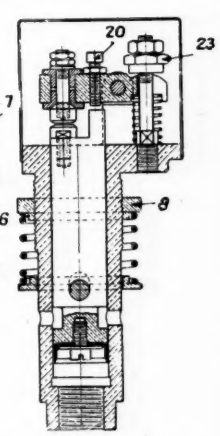


Fig. 10.—Ignition Timing Apparatus.

The pressure in the combustion chamber falls, and the spring (16) returns the small piston to its lowest point, while the plunger (6) brings the dagger to the central position, as shown in the right-hand section. When the next rise of pressure occurs on the cushion stroke, the dagger travels up the right-hand side of the rocker, forcing it over to the left—thus locking the exhaust valve and unlocking the admission valve, to permit a fresh charge of mixture to be drawn into the pump ready for the next cycle. Another reference to the last diagram will now make the application of the mechanism to the pump quite clear.

One form of ignition apparatus is next shown. The device is similar to the operating mechanism in that it is actuated by the rise of pressure in the combustion chamber, and it is of about the

same small size. In this case, however, the piston, which is carried up through the open top of cylinder (1), has a total travel of only one-eighth inch. As the piston commences to move upwards, it makes electrical contact between the earthed contact (13) and the insulated contact (12). The current passes, but only for an instant. For, travelling further, the extended part of the piston meets the stop-screw (20), breaking contact and causing a spark at the ignition plug in the top of the pump combustion chamber. The adjustment of the stop-screw (20) and of nuts (23 and 8) gives perfect control of the timing of the spark.

I have described the ignition apparatus (fig. 10), operating mechanism (fig. 9), and locking gear somewhat in detail, although there is nothing in these particular designs that is essential to the principle of the Humphrey pump. They are of general interest, and show, I think, that essence of good design—namely, simplicity. But the point of importance is that these small and light parts constitute the only moving machinery. As a machine and a prime mover, the Humphrey pump is indeed simplicity itself; but the mathematical basis of its working is anything but simple. Here there is no fly-wheel, no crank shaft, there are no bearings, and no connecting rods to constrain the movements of the piston. The piston is a column of liquid, and, apart from the direct-acting steam pump, the Humphrey pump is, I believe, the first successful free piston engine. But freedom, as the modern philosophers tell us, is an illusion, and can never be more than relative. The water piston in the pump is subject to two compelling forces—at one end varying gas pressures act upon it, and throughout the unvarying "force of gravity."

Resultant Kinetic Energy.

To anticipate mathematically what will happen in a Humphrey pump of a particular design, and working under perhaps variable conditions, involves some fairly complex calculations. It might appear that a new design must necessitate methods of a nature more than usually empirical. But mathematical knowledge and research of no mean order have been brought to bear upon the various problems. Empirical assumptions are but little needed and utilized, and it is found possible to proportion a pump for a given set of conditions with remarkable exactitude. At the outset, such a calculation involved a long and tedious analysis of the forces, masses, and velocities in the water column. Moreover, a certain element of trial-and-error method was necessary; and

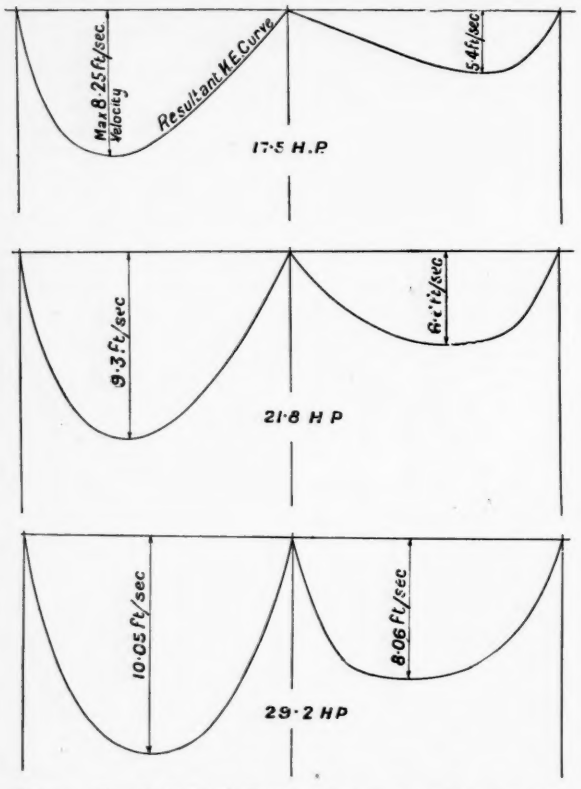


Fig. 11.—Resultant Kinetic Energy. Curves Illustrating Graphical Method of Calculation.

this meant that any given calculation might absorb an abnormal amount of valuable time. Gradually, after several months of patient effort, graphical methods have been adopted, and by the aid of simple draughting devices and sheets of curves standardizing and tabulating all possible calculations of an arithmetical nature, such a system of calculation has been brought to perfection. This is not only tenfold shorter and, as will be seen, to a large extent self-checking, but it also enables a broad view of the subject to be taken.

The next illustration gives a good example of my meaning. It should be explained here that for convenience each calculation is made on a "basis" pump—that is, on an imaginary pump having, as far as possible, proportions which lend themselves readily to mathematical treatment. The proportions of the actual pump are then deduced with the aid of quite simple formulæ. This method has proved itself thoroughly reliable in practice, and I may cite the case of a pump designed to deliver 10,000 cubic feet of water per hour to a head of 20 feet, which, under test at a head of 23 feet, delivered 9750 cubic feet per hour. On a horse-power basis, this is just over 6½ per cent. more than the rated output.

The three curves illustrated are all taken from graphical calculations on a basis pump of the same size but differently arranged in each case. The average ordinate of each of a pair of curves is a measure of the work done on a stroke of the pump, the ordinates of the curves representing net kinetic energy plotted on a time basis—the determination of the time taken in making the stroke is one of the principal objects of the calculation. In comparing the three pairs of curves, one is immediately struck by their progressive symmetry; and this is seen to coincide with an increase in output. The graphical method thus gives at a glance an indication of the correctness of the proportions of the pump chosen, as well as a short cut to the desired result.

The Four-Cycle High-Lift Pump.

I have now to describe the high-lift Humphrey pump. When the head against which the pump works exceeds the mean pressure of the explosion, it is necessary to utilize at the delivery end the device already familiar on the cushion stroke at the gas end—namely, the raising of the pressure by storing energy in a trapped volume of gas or air. Fig. 12 shows the method clearly. The explosion end is in every particular the same as that already described; but at the delivery end, instead of the taper water-tower, we have the "intensifier" H. In the air vessel M, surrounding the delivery valves D, the pressure is automatically maintained to that of the delivery which takes place as a practically continuous flow through the pipe O.

On the outward swing of the water column, the air-valve R is shut by the

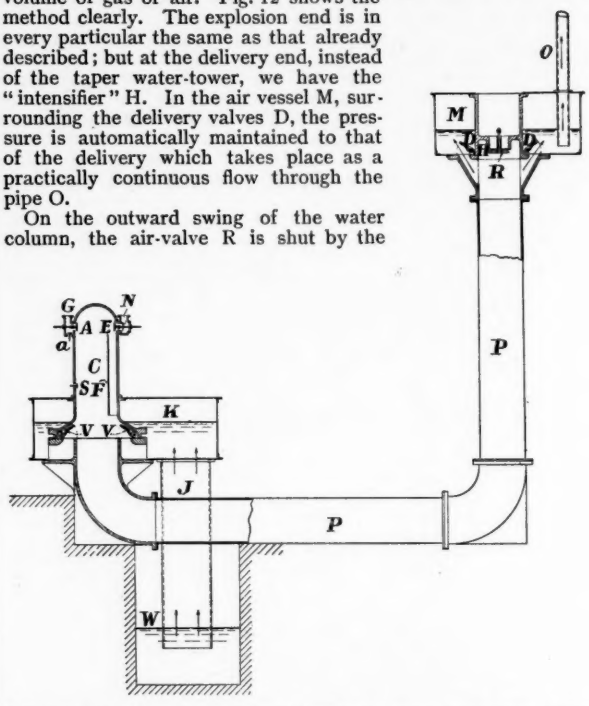


Fig. 12.—The Humphrey Four-Cycle High-Lift Pump (Intensifier Type).

rising water, and the air trapped in H is first compressed to that corresponding to the head, and then water is delivered through the valves D. As the column comes to rest, these valves quietly close; the water within the system starts to return; and when the pressure in H has fallen to that of the atmosphere, the valve R drops open once more. The rest of this stroke, and the other two strokes of the cycle, take place exactly as in the simple pumps described.

In the early types of high-lift pumps, the energy of the compressed air cushion was relied upon to give the two return strokes; but it has been found that, with the intensifier raised as shown, a very small air cushion H only is needed. In such case, the head due to the difference in levels of the intensifier and combustion chamber gives the return energy for the cushion and compression strokes. A pump of this type has been worked with varying suction levels and delivery heads to test it for flexibility. It worked quietly and steadily with a slightly variable suction lift and through a range of delivery heads between 40 and 200 feet without any adjustment or attention whatever. Two such pumps of considerable size are on order for the sewage disposal works at Southend; and one of these will shortly be set to work.

As might have been expected, it has been, commercially speaking, an uphill fight to break down the prejudice and timidity which all new departures from the beaten track must, I suppose, encounter. In the case of the Humphrey pump, the novelty of principle and practice is so pronounced that the initial struggle for a footing has been perhaps more than usually severe. I am glad to be able to say, however, that the number of pumps now installed or under construction for commercial purposes insures the establishment of this invention not only as a powerful factor

in the pumping world, but also as a further nail in the coffin of steam and a justification of those who have pinned their faith to the future triumph of gas power.

The paper was illustrated by lantern slides and models, and before reading it Mr. Birkett said it was at first suggested that Mr. Humphrey should give the paper himself. He was, however, not only an extremely busy man, but the state of his health was such that he was unable to carry out the idea, and asked him (Mr. Birkett) to fill his place, as far as he could do so. During the delivery of the paper, Mr. Birkett referred to a big installation of Humphrey pumps which is being put down in connection with the new Chingford Reservoir of the Metropolitan Water Board, and extended an invitation to the members of the Association to go down and inspect these pumps at a convenient date after the opening of the reservoir by the King—which ceremony will take place about the middle of March.

DISCUSSION.

The PRESIDENT (Mr. D. J. Winslow, of Lea Bridge) said they were much indebted to Mr. Birkett both for the paper and for the invitation to visit Chingford. When they had seen the pumps actually at work, the members would no doubt better understand the principle of the apparatus. The paper was written very clearly; but the whole thing was so novel that he was afraid they could hardly follow all the details.

Mr. J. HEWETT (South Metropolitan Gas Company) said a certain amount of energy was capable of being produced from the quantity of gas consumed, and he would be glad to know how the efficiency of the pump worked out.

Mr. G. F. COX (Commercial Gas Company), on the same point, remarked that with ordinary gas-engines they understood the theoretical amount of gas required per horse power; but an arrangement of this description was novel to most of them. In the paper mention was made of the gas being drawn into the combustion chamber; but he presumed a certain amount of pressure was required to force it in. If so, what pressure was used? For starting, was the gas forced in by a hand pump, or what plan was adopted?

Mr. J. G. CLARK (Gaslight and Coke Company) asked whether the pump was capable of handling very dirty water, containing solids. Also, with regard to the form of the expansion curve, how did this compare with that of the ordinary gas-engine? It would seem, on account of the presence of water in the combustion chamber, that the pressures would be modified by the cooling effect.

Mr. W. E. BROWN (Gaslight and Coke Company) wondered whether any effect was produced by the products coming into contact with the water—assuming that they did so.

Mr. W. NEWTON BOOTH (Woolwich Arsenal) said that personally he was much struck with the progress that had been made in detail of design since he saw the first description of the pump by Mr. Humphrey, some couple of years ago; and he could only admire the ingenuity that had been brought to bear on the problem—especially in connection with the interlocking gear and ignition timing apparatus. Reference was made in the paper to the flexibility of the pump. Could Mr. Birkett say how the flexibility affected the efficiency, because it was well known, in the case of the centrifugal pump, that the head and volume dealt with affected the efficiency to a considerable extent. Then, how was the flexibility of load obtained, seeing that the speed of the stroke—that was, the periodicity of the oscillation of the water column—depended absolutely on the size of the pipes, and therefore constant variations in the load must be obtained by altering the length of the stroke. How was the length of the stroke altered? Could the pump be arranged to work in connection with a suction producer?

Mr. D. C. CROSS (Lea Bridge District Gas Company) inquired what was the limit of length of suction with which the pump could be used; and what was the highest pressure that was obtained at the inlet of the combustion chamber on the back-lash. As to the heating of the cylinder of the combustion chamber, the water did not come into contact with this, and he thought it must, as the gases exploded, get hotter and hotter. What was the heat to which this cylinder attained? Again, how often did the valves need to be taken out and cleaned and reground? With the explosions, the valves must get pitted, and this would affect the efficiency of the arrangement.

The PRESIDENT asked whether the pumps had been made in very small sizes, for ordinary modest requirements. On the curves the same pump appeared to give horse powers varying from 17½ to 29. At least he understood it was the same pump, and this was more or less borne out by the paper, which stated that a pump had worked through a range of delivery heads between 40 and 200 feet, without any adjustment or attention. This almost pointed to some special kind of governing action; but he did not hear any particular remarks on this matter. He would like to know whether the pump had been tried on ordinary tar. He thought they could promise Mr. Birkett a very good discussion when they got to Chingford. He would like to hear something about indicated horse power and brake horse power. Of course, as gas men they welcomed this apparatus, though he supposed it could be worked with producer gas.

Mr. CROSS: If you are pumping sewage, what happens if some of the matter gets underneath the flap-valve? Do you have to stop the pump and clear the valves now and again?

Mr. F. A. FROST (South Metropolitan Gas Company) said he took it that, in the event of one valve getting stuck, all the water in the tube was lost; and it seemed to him that it might be an advantage to have a stop-valve in the pump-pipe.

Mr. BIRKETT, replying to the numerous questions that had been asked, said, as to the efficiency of the pump, the only efficiency they dealt with was thermal efficiency. They did not have any brake horse power or indicated horse power. They only had water horse power. Water horse power was good enough for all practical purposes; so that when he spoke of efficiency, he meant thermal efficiency, which was the equivalent work of the water raised divided by the heat in the gas. The best result ever measured was 23 per cent.; and this represented in practical working the efficiency they got out of the gas-engine—brake-horse-power-hours divided by the heat in the gas. So the efficiency of the Humphrey pump was more than the efficiency of the gas-engine driven pump by the amount that was lost in the driven pump. Knowing that what one lost in the driven pump—centrifugal or any other kind—varied from 20 to 60 per cent., it would be gathered that the Humphrey pump was the most economical method of pumping ever devised. As he had said, the best figure they had obtained was 23 per cent.; and they could do 20 per cent. at any time. They had, in fact, given a guarantee to the Metropolitan Water Board that the efficiency should be 20 per cent.—that was to say, that they should do a water-horse-power-hour on a consumption of 1·1 lbs. of coal. He believed, however, with these pumps, they would come down to 0·8 lb. of coal, which would be equivalent to about 26 or 27 per cent. thermal efficiency. A question had been put as to the quantity of gas burnt. Well, he did not think in cubic feet of gas. He thought in British thermal units and in thermal efficiencies, because they had all sorts of gases to deal with. They were asked to supply pumps to run on town gas of 500 to 600 B.Th.U. per cubic foot, right down through coke-oven gas of about 400 B.Th.U., producer gas of 150 B.Th.U., suction gas of 110 B.Th.U., to blast-furnace gases of about 90 B.Th.U. Therefore it would not be much use thinking in cubic feet of gas. Taking 23 per cent. as the best result, this represented some 11,050 B.Th.U. per water-horse-power-hour; and reckoning it on the basis of suction gas of 110 B.Th.U. per cubic foot, this represented 100 cubic feet of that gas per water-horse-power-hour. Or with gas of 550 B.Th.U., which most of the members were probably more familiar with, it meant 20 cubic feet per water-horse-power-hour. As to how the gas was drawn in, and at what pressure, the Humphrey pump took gas in exactly the same way as did a gas-engine. In fact, they had done a lot of work on producer gas; while they had also been most successful on town gas, and they had got exceedingly good results on suction gas. A point had been raised as to the method of starting the pump. This was quite simple. A charge was blown into the combustion chamber by a compressor. At Chingford, they would find the pumps provided with a small electrically driven compressor, which, of course, was minute compared with the size of the pump, and only worked for about half-a-minute. This gave a charge of gas sufficient to obtain a good stroke. If, however, it was preferred, they could for a small unit pump in only air, and force open the exhaust-valve. Then the air would escape and the water rise, and the next stroke would draw in the charge of gas. Certainly, dirty water could be pumped. Elaborate experiments had been made with water containing all sorts of things, and nothing much had happened. They never managed to stop the pump by blocking the valves. He recalled a case in Italy, where the pump was "going through its paces," and several bags of long, hard leaves, or reeds more than anything else, were put into the suction pit of the pump, and the water circulated back from the water-tower to the pump-pit. The pump worked in this way for three or four hours, and then the reeds were found to have been chopped to pieces by the valves. This was all that happened. With reference to how the expansion curve compared with that of the gas-engine, as far as the first portion was concerned, it was exactly the same. The distinction was that the expansion was continued to atmospheric pressure. The consequence was that they took advantage of the toe of the diagram, and to a large extent this was where their high efficiency came from. As the result of very careful tests, it had been found that there was no contamination of the water, even with gas containing a lot of tar, &c. Another query was as to the flexibility of the pump, and how this affected the efficiency. To answer this fully would take rather a long time; but he could reply to it in a short way. A pump which would work from 10 to 35 feet (which amounted to the practical limit for the simple type) would have an approximately straight-line curve of efficiencies from the first to the highest lift. That was, supposing they got 12 per cent. thermal efficiency with a 10-feet lift, as they raised the lift from this to 35 feet the thermal efficiency would go up from 12 to 24 per cent.—more or less proportional to the lift. With the intensifier type pump, there was not very much difference. Practically speaking, the efficiency was constant throughout the range—the efficiency might even increase in the higher lifts. They varied the volume that was pumped by varying the stroke. By increasing the length of the stroke, the output was increased; and the shorter the stroke, the smaller was the quantity of water pumped. With the high-lift type, they could keep the pump running without pumping at all, with very small charges. He mentioned in the paper that with a simple suction pump, the practical limit of suction was for various reasons from 8 to 10 feet. Special types of pumps which he had not illustrated, because they

were still in the experimental stage, had been worked-down to 25 or 26 feet suction; but for practical purposes at the present time the limit was as he had stated. As to the highest pressure in the cushion, they tried to keep down to 120 or 130 lbs. The heat on the top of the cylinder never rose beyond what could be borne by the hand when the pump was working—it was just a comfortable heat. How often the valves had to be reground depended largely on the quality of the water pumped, the way in which they were treated, and so forth. But, as he had pointed out in the paper, the valves opened and shut with very slight differences of pressure. There was therefore no banging; and there was no reason, with good material and clean water, why they should not last practically for ever. This referred to the water-valves. The gas-valves also closed and opened quite quietly; and as the temperatures were not high, they were certainly likely to have a good deal longer life than gas-engine valves. For ignition purposes, hitherto they had mostly used a coil, which had given great satisfaction. It was only recently that they had turned their attention to the magneto system; but they had had very good results from it so far, and hoped to get still better. He did not know whether the member who had put a question about clearing the apparatus in case of sewage pumping had had any experience of centrifugal or other pumps for this work. If so, he knew that all pumps when working in stuff of this kind had to be stopped for clearing from time to time. The Pump and Power Company had managed to design a valve with a very clear open water-way; and he did not know why efficiently screened sewage should not be successfully dealt with. They would have practical experience on this matter shortly, from the pump mentioned in the paper which was being put down in Kent. They had not so far made pumps in very small sizes. The smallest was of a capacity of 300 gallons a minute; but there was no reason why they should not be made smaller. The horse power of the pump was fixed by the amount of charge; and when the lift to which the pump was working was increased, the quantity of water pumped was decreased, and consequently the horse power remained practically constant. They had tried to pump most things; but tar was not one of them. If one of the valves got stuck, when the pump stopped certainly most of the water in the pumping system would be lost. The water in the delivery reservoir, however, would not be lost, because it was shut off by a valve. If they lost the water in the pumping system, all they had to do was to pump some more.

At the conclusion of the discussion, Mr. Birkett was accorded a hearty vote of thanks, on the proposition of Mr. T. F. CANNING (Ilford), seconded by Mr. CLARK—both of whom spoke in appreciative terms of the invention that had been so lucidly described to the members.

Lighting of Factories and Workshops.

It was announced last Wednesday that the Home Secretary had appointed a Committee to inquire and report as to the conditions necessary for the adequate and suitable lighting (natural and artificial) of factories and workshops, having regard to the nature of the work carried on, the protection of the eyesight of the persons employed, and the various forms of illumination. The members of the Committee are:

Dr. R. T. Glazebrook, C.B., F.R.S., Director of the National Physical Laboratory (Chairman).
Mr. Leon Gaster.
Professor Francis Gotch, D.Sc., F.R.S.
Mr. J. Herbert Parsons, M.B., D.Sc., F.R.C.S.
Mr. W. C. D. Whetham, F.R.S.

Sir Arthur Whitelegge, K.C.B., Chief Inspector of Factories. The Secretaries of the Committee are Mr. D. R. Wilson, one of His Majesty's Inspectors of Factories, and Mr. Clifford C. Paterson, M.I.Mech.E., Assoc.M.Inst.C.E., of the National Physical Laboratory.

"Selas" Gas Lighting in Belfast.

A report appears on another page of this issue of the proceedings at the inauguration of the new plant on Monday of last week at the Ormeau Road Gas-Works, Belfast; and in connection with this, it may be stated that a "Selas" installation was fitted up for the lighting of the improvised dining-hall—the admirable appearance of which, and the brilliant and steady lighting, were generally acknowledged. The apparatus was a 10,000-candle power "Selas;" the lamps in the dining-hall (of which there were forty) being of the 100-candle power type. The compressor was driven by a 1½-H.P. Waller gas-engine. With this system, the gas is taken in from the town mains, and reduced to atmospheric pressure by a special counterbalanced diaphragm governor. The air is taken from the exterior of the building, and both gas and air are then dealt with by a cylindrical double-ported control valve, which can be set to give any mixture required. The gas and air mixture is next delivered at a pressure of 10 inches water-column only, and sent through the delivery pipes to the burners in practically a combustible mixture. There are now over forty plants installed in Belfast; and they are giving every satisfaction. In four instances they have replaced electric generating plants, over which they show a considerable saving. It may be added that the "Selas" system is being installed in City Hall.

NATURAL GAS IN HUNGARY.

In the "JOURNAL" for the 13th of August last (p. 451), there appeared a review of a book prepared by Dr. Strache, at the request of the Austro-Hungarian Association of Gas and Water Engineers, containing a record of the advances in lighting and in the gas industry in 1911, and furnishing some interesting information in regard to an occurrence of natural gas in Hungary, and on projects for its utilization. By a rather curious coincidence, the same issue contained an announcement, on the authority of the "Financial News," that negotiations were in progress between an English syndicate and the Hungarian Minister of Finance for a concession to work the important natural gas deposits at Kissarmas. An article on "Natural Gas in Transylvania" appeared in a recent issue of an Italian publication devoted to mineral subjects, and from it the following particulars have been obtained.

While boring for potassium salts near Kissarmas in 1909, emanations of methane were met with at no great distance from the surface. They became more abundant at increased depths, until, at rather more than 900 feet, there was a violent inrush which made it necessary to stop work. But instead of a deposit of potassium salts there was a gas spring, which proved to be one of the most productive in the world, yielding 860,000 cubic metres of a 99 per cent. methane gas daily. The Hungarian Government, realizing the importance of the discovery, purchased the land, and by Act of Parliament made the natural gas industry a State monopoly. A geological survey of the district was carried out, and it was fully proved that the seat of the gas is in the miocene saliferous formation, constituted of the same variety of marl as that which contains gas in Upper Austria, Galicia, Moravia, and Silesia.

As soon as the laws governing the deposits were ascertained, it was possible to locate the new springs with almost absolute certainty. Up to the present time, the following large springs have been tapped:

Place.	Depth. Metres.	Depth. Feet.	Daily Production. Cubic Metres.	Daily Production. Cubic Feet.
Kissarmas	300	984	860,000	30,371,000
,,	68	223	55,000	1,942,000
,,	80	262	65,000	2,295,000
,,	225	738	204,000	7,204,000
,,	108	354	70,000	2,472,000
,,	119	390	105,000	3,708,000
,,	129	423	160,000	5,650,000
,,	220	721	76,000	2,684,000
Mediasch	102	334	18,000	635,000
Magyar Saros	153	502	196,000	6,912,000
Baaben	140	459	55,000	1,942,000
Samsond	72	236	6,000	212,000
,,	215	705	170,000	6,004,000
Kishalus	117	383	86,000	3,037,000

Other springs, some of which are still being bored, have yielded smaller quantities.

The large daily production now assured assumes even greater proportions when it is considered that it can be increased by boring deeper, in most instances, because the gas exists in sandy beds in the marl. Several borings demonstrated that there is often a great quantity of gas sand extending to a very considerable depth. Consequently, the deeper the boring the greater the number of gas reservoirs met with. In some cases boring has been stopped as soon as the presence of gas made itself apparent, the means for its utilization not being available. To get a larger production, all that will be needed will be to bore deeper.

In estimating the value of the Transylvania springs, the observation made at Kissarmas is of great assistance. During two years the boring daily gave 860,000 cubic metres of gas. Now that it has been closed so that the gas cannot develop, the gauge indicates a constant pressure of 27 atmospheres, which did not decrease when another boring was made only about 650 yards away, giving a daily production of 204,000 cubic metres.

Geological survey demonstrates that the anticlinal line upon which Kissarmas is situated extends for a length of 51 miles. It was also ascertained by survey that besides the Kissarmas anticlinal there are at least eighteen others, similar in form and dimension, within the probable gas zone. A long life may reasonably be assumed for the natural gas industry of the country.

Midland Junior Gas Association.—The announcement is made by the Hon. Secretary (Mr. W. J. Pickering) that a dinner has been arranged to take place at the Colonnade Hotel, New Street, Birmingham, on Saturday evening, Feb. 8. After dinner, an address will be delivered by Mr. J. Ferguson Bell, of Derby; and a musical programme will follow the address.

Reports of Gas Associations for 1912.—As announced in another part of the "JOURNAL," this work is now ready. The volume contains the collected reports, as given in our columns, of the proceedings at the meetings of the various District Gas Associations held in the past year. The technical matter occupies 580 pages, and is illustrated by 44 figures, a number of diagrams, and three folding plates. Reference to any subject is facilitated by an index; and at the end of the book are given lists of the officers and members of the Associations. The volume, which is the thirtieth of the series, will form a useful companion to the "Transactions" of the Institution of Gas Engineers.

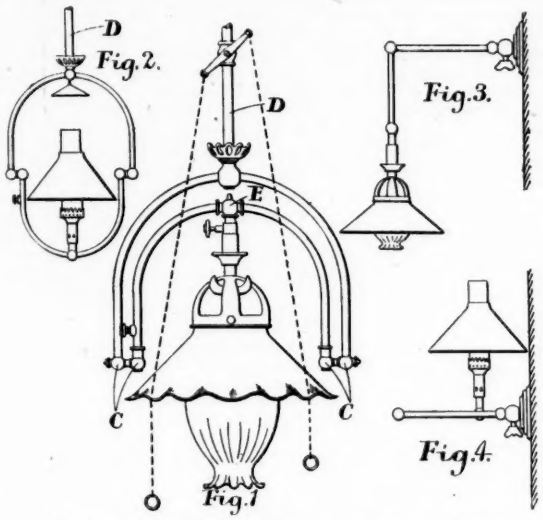
REGISTER OF PATENTS.

Adjustable Gas Pendants and Brackets.

CULLING, P. E., and SPREADBURY, E. L., of Weston-super-Mare.

No. 29,164; Dec. 28, 1911.

These adjustable gas pendants and brackets comprise "two limbs or bows jointed together at their extremities and adapted to be locked in adjusted relative positions—the one being connected to the supply and the other to the burner."



Culling and Spreadbury's Adjustable Gas-Pendant Brackets.

Fig. 1 represents a pendant in the folded position; and fig. 2, the pendant extended (carrying an upright burner). Fig. 3 represents a fitting serving as a wall bracket and extended to carry an inverted burner; while fig. 4 represents the fitting in the folded position and carrying an upright burner.

The pendant comprises two bows or limbs connected one to the other at their respective extremities by swivel joints C. The outer limb is secured at the middle of its length to a supporting member D connected to the gas supply. The inner limb is connected by a swivel joint E to a socket by which the burner is carried. The position of the burner may be adjusted by tightening nuts in connection with the swivel joint. Similarly the limbs may be adjusted at any angle one to the other by tightening nuts at C.

Effecting the Mutual Reaction of Sulphuretted Hydrogen and Sulphurous Acid.

FELD, WALTHER, of Linz-on-the-Rhine, Germany.

No. 157; Jan. 2, 1912.

In his patent No. 5838 of 1911 the inventor describes a process for combining ammonia (alone or together with sulphuretted hydrogen) with sulphurous acid—the conditions of the process being such that ammonium thiosulphate, polythionate, and sulphate are produced, but no ammonium sulphite. A mode of carrying out the process consists in treating a polythionate solution alternately with sulphurous acid and with gases which contain ammonia with, or without, sulphuretted hydrogen. The polythionates act also to oxidize and separate sulphur from any sulphuretted hydrogen which may be present in excess of the equivalent quantity of ammonia present in the gases. In the process a part (or the whole) of the thiosulphate resulting from the absorption of the ammonia and sulphuretted hydrogen is, by means of sulphurous acid, again converted into polythionate; and in case sulphurous acid passes into the gases, such acid is washed out by treating the gas with a thiosulphate solution.

He has now found that sulphuretted hydrogen contained, without ammonia, in gases, vapours, or liquors, can be oxidized by means of sulphurous acid, and that sulphur can be obtained if both the sulphuretted hydrogen and sulphurous acid be caused to act simultaneously (or successively) on solutions of thiosulphates, even if these do not contain polythionate. It is known that if sulphurous acid and sulphuretted hydrogen be passed through water, or through certain salt solutions, they are caused to mutually react. The action which takes place is generally expressed by the equation—

$$2H_2S+SO_2=2H_2O+3S.$$

This equation, however, cannot be considered to be a true indication of the reaction. Only a small part of the reaction may be considered to occur in the manner indicated, as mainly various thionic acids are produced along with some sulphuric acid. The free sulphur produced is probably mainly a secondary product of decomposition of the thionic acids primarily produced. The mutual reaction of sulphuretted hydrogen and sulphurous acid is incomplete, and with the accumulation of free acids in the liquor, the reaction is correspondingly further retarded, and large amounts of both gases escape the reaction.

If, for instance, ordinary coal gas, in order to be purified, is treated with such an amount of sulphurous acid as is in accordance with the process referred to, the gas absorbs sulphurous acid; but the reaction of the sulphuretted hydrogen contained in the gas with the sulphurous acid supplied is incomplete. Complete extraction of sulphuretted hydrogen from coal gas by treating it with sulphurous acid therefore has not been obtained. Furthermore, the reaction according to the foregoing equation, could not be carried out in practice, as it is practically impossible to mix the two components in the ratio required by it. One or other of the components will always be in excess, and will contaminate the gas. For these reasons all attempts hitherto made to carry out the mutual reaction have failed.

Herr Feld has found that the presence of a thiosulphate supports substantially the mutual reaction of sulphuretted hydrogen and sulphurous acid. In order to complete the oxidation of the sulphuretted hydrogen, for each two molecular proportions of sulphuretted hydrogen at least one molecular proportion of sulphurous acid—that is, for one part by weight of sulphuretted hydrogen at least one part by weight of sulphurous acid—must be supplied. Any excess of sulphurous acid does not prejudice the reaction, and is completely neutralized by the thiosulphate—mainly polythionate, and occasionally some sulphate, being formed. The completeness of the reaction is not prejudicially affected if, in addition to sulphuretted hydrogen, ammonia be also present in the gases; but the amount of sulphurous acid must then be increased accordingly. At least two proportions by weight of sulphurous acid are employed to each proportion by weight of ammonia. Also in this case any excess of sulphurous acid is neutralized by the formation of polythionate; any deficiency being compensated for by any polythionate present which may have been formed owing to any excess of sulphurous acid having been present. Any polythionate present in the thiosulphate solution will support the reaction between the sulphuretted hydrogen and sulphurous acid.

Although, for the purposes of the present invention, the thiosulphate of any base, or a mixture of such thiosulphates, or of such thiosulphates with other salts (such as sulphates, chlorides, or polythionates), may be used, it is advisable, the patentee remarks, to use alkali thiosulphates, alkaline earth thiosulphates, ammonium thiosulphate, or magnesium thiosulphate. If the gases to be treated also contain ammonia, ammonium thiosulphate is preferably employed. There is no injurious influence on the reaction if the liquor contains sulphate, polythionate, chloride, or other ammonium salts.

The following example illustrates how the invention can be carried out, for instance, with coal gas which is to be deprived of sulphuretted hydrogen: The gas to be purified is treated in a gas-washer with a solution of ammonium thiosulphate. The solution is, simultaneously with, or prior to, being introduced into the gas-washer, treated with sulphurous acid. If the gas is to be completely freed frum sulphuretted hydrogen, an excess of sulphurous acid is employed. Sulphurous acid which does not enter into reaction with the sulphuretted hydrogen will be neutralized by the thiosulphate, and polythionate be thereby formed, The formation of polythionate is of especial advantage when the gas contains ammonia in addition to sulphuretted hydrogen. In so far as the ammonia has not already been dissolved to thiosulphate by a part of the excess of sulphurous acid in co-operation with the precipitated sulphur, such ammonia will be absorbed by the polythionate, which will be reduced to thiosulphate. If, however, there be no ammonia in the gas, it is advisable to prevent too much polythionate accumulating in the solution by reducing the polythionate to thiosulphate. To effect this, the liquor which contains the polythionate, and which runs from the washing apparatus, is treated with raw gas which contains sulphuretted hydrogen, or ammonia, or sulphuretted hydrogen and ammonia. Or the polythionate can be reduced to thiosulphate by treating the liquor with basic, or reducing, compounds—such, for instance, as ammonia water, or milk of lime, or with soluble, or insoluble, sulphides, or the like. After the greater part, or the whole, of the polythionate is again reduced to thiosulphate, the liquor is ready for re-use; but, as already stated, it is not necessary to have all the polythionate reduced. The liquor can be used in either an alkaline, neutral, or acid condition.

The gases and the solution of thiosulphate entering into mutual reaction may be cold or hot. When operating at a high temperature, it is advisable to avoid, as much as possible, the formation of polythionate, as, under the action of heat, part of the polythionate may be converted into sulphate. Although sulphates have no injurious influence on the reaction, the efficiency of the liquor is diminished if the amount of thionates (thiosulphates and polythionates) be reduced by such formation of sulphate. In this case, it is advisable to supply to the gas, or to the thiosulphate solution, less sulphurous acid than corresponds to the sulphuretted hydrogen, although then some sulphuretted hydrogen will remain in the gas. But this can be removed by subjecting the gas, while still hot, or after it has been cooled if required, to a further treatment with a solution of thiosulphate and sulphurous acid containing an excess of thiosulphate, or directly with a polythionate solution.

In purifying gases which contain much ammonia in addition to sulphuretted hydrogen, the process, according to the present invention, can, with advantage, be combined with that according to patent No. 5838 of 1911. In this case, the gas is treated first according to the process described in the patent, and then any excess of sulphuretted hydrogen is extracted according to the process of the present invention. Thiosulphate liquor may also be treated with a large excess of sulphurous acid and, at the same time, or subsequently, with the gas already freed, partly or wholly, from ammonia. The part of the sulphurous acid which has not been utilized in the oxidation of sulphuretted hydrogen then forms polythionate; the solution of such polythionate then being used, in accordance with the earlier specification, to extract ammonia and a part of the sulphuretted hydrogen from the raw gas. By this treatment, the concentration of the thiosulphate liquor is increased in proportion to the amount of the ammonia contained in the gas. By the increase of concentration—especially if the operation be carried on with the application of heat—the speed of the mutual reaction of sulphuretted hydrogen and sulphurous acid is somewhat decreased. By drawing off, from time to time, part of the concentrated liquor and adding fresh water, or ammonia water, or diluted liquor, or the like, the proper concentration can be restored. The ammonium thiosulphate in the concentrated solution drawn off is transformed into sulphate, as described in the 1911 patent. The precipitated sulphur resulting from the reactions is, from time to time,

separated from the thiosulphate liquor, and can be burned to form sulphur dioxide, or be used for other purpose.

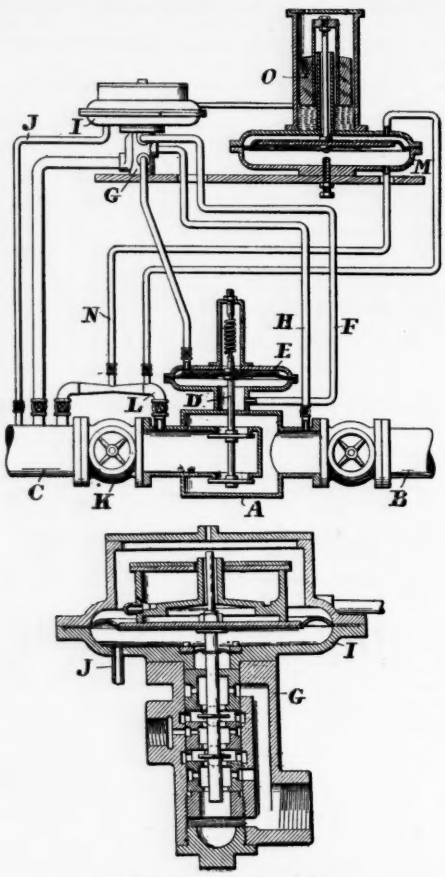
In carrying out the invention, the patentee remarks in conclusion, sulphurous acid of any concentration or origin can be employed; and it can be introduced directly into the gas to be treated before, or while, the gas is treated with the solution of thiosulphate. The gases and liquor may be caused to act in either counter or parallel currents; the latter being preferable. The pressure of the gases to be treated with the liquor may be above or below atmospheric pressure; and the liquor may be injected into the gases, or applied in a horizontal, centrifugal, or other washer.

Pressure-Regulating Means.

LLOYD, E. F., of Detroit, Michigan, U.S.A.

No. 482; Jan. 6, 1912.

This invention relates to means for automatically controlling the flow of gas through a main whereby the pressure at any given point is made to build-up as the volume of gas passing such point increases. Broadly, the invention consists in "the combination with a conduit, of regulating means controlled by gaseous pressure for automatically maintaining a constant pressure in the outlet side of the conduit, means for controlling the admission of gas under pressure to operate the regulator, means for setting-up a drop in pressure in the conduit, and means controlled by variations in the drop in pressure and adapted to control the pressure-fluid admitting means by gravity to raise the pressure in the conduit as the flow past the point of drop increases."



Lloyd's Pressure Regulator.

The illustrations are a view (partly in section and partly in elevation) of the entire apparatus and a view in section of the master valve.

As shown, a main or conduit has an automatic regulating valve A that controls the flow from the inlet arm B of the main to the outlet arm C, and holds the pressure in the latter arm under ordinary conditions at a constant point in relation to atmospheric pressure. The pressure in the inlet is higher than that in the outlet. The valve has a pair of plates adapted to close on annular seats in the valve casing. The stem D, carrying the closures, operatively connects them to a movable or flexible diaphragm E that divides a drum into an upper and a lower compartment. A tension spring in a tubular extension of the drum may be adjusted on a suspending screw-threaded rod to exert a constant pull on the diaphragm.

A pipe F connects the lower compartment of the drum with one outlet of a master valve G, and the other drum chamber is in communication with another outlet of the same valve. A pressure or power gas pipe H connects the inlet of the master valve with the high-pressure or inlet arm B of the conduit or other source of gas supply under pressure; and a waste pipe leads from an exhaust opening in the valve to the low-pressure arm C. The master valve is made with a stem extending through a packing diaphragm into a drum I, and is connected to a flexible diaphragm in the latter, whereby the pressure of gas introduced beneath it through a pipe J from the outlet arm of the conduit acts to raise the stem against weights placed on the stem.

Thus as the pressure increases in the outlet arm of the main, the tendency of the master valve is to shunt gas from the pressure or power gas pipe H through the pipe F under the lower side of the diaphragm E, and thereby close the latter correspondingly. The gas in the upper compartment of the drum escapes into the lower pressure arm of the conduit or elsewhere. Conversely, when the pressure in the outlet arm of the conduit falls, the master valve tends to deliver the power gas on to the diaphragm E, and open the regulating valve correspondingly. The weights on the closure stem of the master valve determine the range of action of the governor, which tends to hold the pressure substantially constant in the outlet arm. Such pressure is termed "normal" or "set."

In order, however, that the regulator may allow the pressure to increase as the volume of gas passing through the outlet increases, means operated by an artificial or local drop in pressure at a given point (preferably in the outlet arm) are employed to increase the weight on the master valve, and thus cause the latter to open the regulating valve when under "excess pressure" or pressure above the "normal." A valve K forms a convenient and adjustable means for causing the desired drop. A bye-pass L is placed around this point of drop, and a Venturi tube is inserted in the bye-pass for multiplying the effect of the differential or velocity pressure thus obtained. The pipe from the head of the Venturi enters the compartment of a pressure drum M of a loader above a flexible diaphragm. A throat pipe N from the Venturi communicates with the drum below the diaphragm. As the velocity-pressure of the Venturi increases, the resultant downward movement of the diaphragm depresses the float O, thereby forcing the level of the mercury in the chamber up into the narrow annular space between the float and the chamber wall, so that it flows over into the bowl and increases the load on the latter—tending to shunt the power gas to open the regulating valve A. A stop screw limits the downward movement of the diaphragm and displacement float, so that the apparatus may be set to impose only a predetermined maximum of excess load on the master valve.

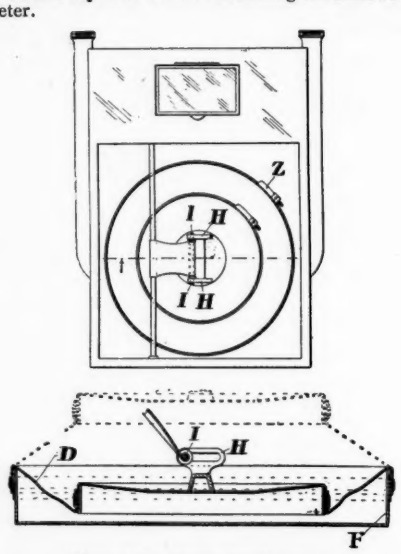
In operation, the regulating is controlled by the master valve to hold a desired pressure in the outlet arm of the main within a range determined by the weights upon the master valve stem. Beyond this range the loader acts to cause a rise and fall of pressure above the "normal" or "set" pressure in exact proportion to variations in volumes of flow. The volume of flow to cause a desired drop may be varied by changing the adjustment of the adjutage valve. In other words, the apparatus has two independent adjustments—one for obtaining the "normal" outlet pressure desired, the other for obtaining the volume of flow desired and for limiting the maximum "excess" pressure to be obtained.

Diaphragms of Gas-Meters.

HOWES, J. T., of Clapham Common, S.W.

No. 6454; March 15, 1912.

This invention is to enable the diaphragm of a dry gas-meter to be easily removed and replaced without detaching the bellows as a whole from the meter.



Howes' Dry Meter Diaphragms.

The meter case, flag pole, and flag are of the usual kind. The diaphragm D is a plain ring cut from a flat piece of material and attached by its outer edge to the non-moving sheet metal ring F—the method of fixing being by a band or strap with a screw nut, and saddle Z, as described in patent No. 14,145 of 1908, while the inner edge is similarly fixed to the return edge of a sheet metal disc G, on which slotted pillars H are mounted. The ends of the roller I on the flag are placed in the slots of the pillars, and the arrangement is such that the diaphragm can be moved from the position shown by full lines to that shown by dotted lines.

Coke Loading and Screening Machines.

FABRY, R., of Sheffield.

No. 9993; April 27, 1912.

This invention relates to a machine whereby the coke discharged from coke-ovens on to an inclined coke bench and quenched thereon can be subsequently separated from its breeze and coke dust and loaded into railway trucks "with a minimum of expenditure in respect of labour, power, maintenance, and repair."

The machine consists of a comparatively short horizontal coke

conveyor, preferably of endless push-plate type, carried by a strong framework mounted on wheels and travelling on a railway track alongside of the coke-bench. The conveyor is purposely arranged so as to be parallel with the lower edge of the inclined bench, and is furthermore continued at one end by an inclined portion (of convenient length and gradient) for enabling the coke elevated on it to slide down a shoot, arranged at right angles with the coke conveyor, direct into any of the trucks standing on a railway track laid parallel with the machine's track.

The coke, the breeze, and the coke dust quenched on the inclined coke-bench slide naturally on to the horizontal portion of the coke-loading machine as soon as the swing doors provided at the foot of the inclined coke-bench are swung down; and the former are then immediately taken up the loading shoot by the push-plate conveyor.

The race over which the coke, breeze, and dust are made to travel is constituted by thin longitudinal screening bars, of trapezoidal section and of such spacing that the breeze and dust are completely separated from the large metallurgical coke and accumulated for subsequent treatment in a hopper of suitable capacity arranged immediately under the screening bars and provided with an easy working discharge register.

APPLICATIONS FOR LETTERS PATENT.

909.—Price, T. E., "Regulators for burners." Jan. 13.

992.—Schanzenbach, G., and Knapp, C., "Globe and reflector." Jan. 13.

1016.—Bowley, J. W., "Measuring flow of liquids." Jan. 14.

1021.—Knight, H. S., and R. & J. Dempster, Ltd., "Gas-producers." Jan. 14.

1104.—Boult, A. J., "Automatic production of water gas in the combustion zone of certain engines." A communication from the Soc. Anon. des Brevets Magnee. Jan. 14.

1117.—Whitfield, C., "Gas-producers." Jan. 15.

1118.—Whitfield, C., "Gas washers or tar extractors." Jan. 15.

1121.—Crossley, Sir K. I., and Fielden, F., "Suction producers." Jan. 15.

1221.—Krauss, F., Brückner, F. V., and Ludwig, E., "Gas-generators." Jan. 15.

1294.—Blose, C. S., "Gas-engines." Jan. 16.

1309.—Soc. Anon. Hongroise de Banke et de Commerce, "Portable gas-generating plant." Jan. 16.

1325.—Lipinski, A. V., "Manufacture of gas." Jan. 16.

1330.—Reitmeister., W., "Valve for regenerative furnaces." Jan. 16.

1348.—Featherstone, W. B., "Automatic inclined producer for the manufacture of coal gas, tar, liquor, and smokeless fuel." Jan. 17.

1354.—Crossley, M. E., "Mantle fork." Jan. 17.

1382.—Theisen, H. E., "Washing gases." Jan. 17.

1384.—Manchester Paint and Varnish Co., Ltd., and Jordan, T. W., "Purification of gas." Jan. 17.

1430.—Franz Meguin and Co. Akt.-Ges. and Muller, W., "Quenching and loading coke." Jan. 17.

1488.—Sir W. G. Armstrong, Whitworth, and Co., Ltd., and Davy, W., "Pipe-joints." Jan. 18.

PARLIAMENTARY INTELLIGENCE.

GAS AND WATER PROVISIONAL ORDERS FOR 1912.

Report by the Board of Trade.

The Board of Trade issued last week a report on their proceedings under the Gas and Water Works Facilities Act, 1870, during the first part of the present session. It shows that in December, 1911, sixteen applications were made for Provisional Orders, eleven relating to gas and five to water undertakings. The amount of capital proposed to be authorized was £347,400 by shares and £117,563 by loan—£189,400 share and £63,397 loan capital being for gas and £158,000 share and £54,166 loan capital for water purposes. The Gas Orders related to Cambridge, Cleethorpes, Conisbrough, Elham Valley, Hatfield (Yorks.), Knottingley, Swansea, Thurles, Tipperary, Welwyn, Knebworth, and District, and West Kent; the Water Orders, to Chiddingfold and District, East Surrey, Elham Valley, Henley-on-Thames, and Wimborne Minster.

GAS ORDERS.

The principal objects of the applications in regard to gas were to confer the following powers upon the respective Companies:

Cambridge University and Town Gas.—To extend the limits of supply, and to authorize the disposal by nomination of stock and deposits held under the Company's co-partnership scheme.

Cleethorpes Gas.—To extend the Company's limits of supply.

Conisbrough Gas.—To empower the Conisbrough Gas Company, Limited, to raise additional capital.

Elham Valley Gas.—To empower Mr. James Francis Kelley and Mr. Cornelius Brittiffe Tully to construct and maintain gas-works, and to manufacture, store, and supply gas within the parishes of Lyminge, Elham, Postling, and Stanford in the county of Kent.

Hatfield (Yorks.) Gas.—To empower the Hatfield (Yorks.) Gas Company, Limited, to maintain and continue existing gas-works, construct and maintain further works, and manufacture, store, and supply gas within the parishes or townships of Hatfield and Stainforth in the West Riding of York.

Knottingley Gas.—To empower the Knottingley Gas Company to raise additional capital.

Swansea Gas.—To empower the Swansea Gas Company to construct and maintain further works for the manufacture and storage of gas.

Thurles Gas.—To empower the Thurles Gas Company, Limited, to maintain and continue existing gas-works, construct and maintain further works, and manufacture, store, and supply gas within the urban district of Thurles and adjacent parishes in the county of Tipperary.

Tipperary Gas.—To empower the Tipperary Gas Company, Limited, to maintain and continue existing gas-works, and to manufacture, store, and supply gas within the urban district of Tipperary and adjacent parishes in the county of Tipperary.

Welwyn, Knebworth, and District Gas.—To empower the Welwyn, Knebworth, and District Gas Company, Limited, to maintain and continue existing gas-works, construct and maintain further works, and manufacture, store, and supply gas within the parishes of Aston, Datchworth, Watton-at-Stone, Tewin, Welwyn, Digswell, Ayot St. Peter, Ayot St. Lawrence, Codicote, Knebworth, and Shephall in the county of Hertford.

West Kent Gas.—To empower the West Kent Gas Company to construct and maintain further works for the manufacture and storage of gas.

Four of these applications—viz, those from Hatfield (Yorks.), Thurles, Tipperary, and Welwyn, Knebworth, and District—were in respect of existing non-statutory undertakings; and the application from Elham Valley was for power to commence an entirely new undertaking. All the other applications were in respect of undertakings already authorized by Special Acts or Provisional Orders.

Opposition.

Objections were lodged with the Board of Trade against all the applications; but those against the Cambridge, Knottingley, Swansea, and Thurles applications were subsequently withdrawn. The objections made in respect of the Cleethorpes, Conisbrough, Elham Valley, Hatfield, Welwyn, and West Kent applications were fully considered, and an inquiry was held at the offices of the Board in each case.

Having regard to the objections put forward by the Tipperary Urban District Council, the Board were of opinion that a local inquiry should be held in respect of the application of the Gas Company. They accordingly appointed Mr. R. J. Doyle, K.C., to hold an inquiry at Tipperary on their behalf, and to report to them on the application. After an inquiry lasting five days, Mr. Doyle reported that, subject to certain modifications and amendments, the application should be allowed to proceed.

The promoters of the Hatfield and Welwyn Orders, having failed to obtain the consent of some of the local and road authorities concerned, requested the Board to exercise their powers under section 4 of the Gas and Water-Works Facilities Act, 1870, and to dispense with the consent of these authorities.

It appeared that the Stainforth Parish Council had refused their consent to the Hatfield application on the ground that cheaper gas than could be supplied by the promoters might in future be obtained from a colliery company who proposed to open a mine in the parish. It was stated, however, that the company would not be working for at least three years. In these circumstances, and in view of the fact that the promoters had been supplying gas in the vicinity for a considerable period, the Board decided to dispense with the consent of the Parish Council, and to grant the Order subject to certain modifications which appeared to be desirable.

In the case of the Welwyn application, the promoters failed to obtain the consent of the Ashton Parish Council and of the parish meetings of Digswell, Shephall, and Ayot St. Lawrence; but the Digswell meeting was the only one of the dissenting authorities which sent representatives to the inquiry. It appeared that objection was taken to the site on which the promoters proposed to erect gas-works, on the ground that the amenities of the district would be injuriously affected. There was no wish, however, to prevent a supply of gas being given in the neighbourhood, and another site was suggested by the objectors. In these circumstances, the Board directed one of their officers to make an inspection of the two sites. He reported that works erected on the site proposed by the promoters would be scarcely visible from the surrounding properties owing to intervening objects, and that trees planted round the site would further cut off any view of the works. The other site suggested, being at a somewhat higher level than the railway, as well as in an isolated place, would prove expensive to work, thus causing an increase in the cost of manufacturing gas. After considering this report, the Board decided to grant an Order, subject to the insertion of a provision requiring trees to be planted round the site, and dispensed with the consent of the dissenting local authorities.

Having been satisfied that all the applications made to them should proceed, the Board granted the Order applied for in each case, subject to such modifications and amendments as seemed to be required.

Price of Gas.

In the following Provisional Orders, a maximum price per 1000 cubic feet of gas was fixed: Elham Valley, 5s.; Hatfield, 5s.; Thurles, 5s. 7d.; Tipperary, 5s.; Welwyn, Knebworth, and District, 4s. 4d. In the Knottingley Order, a standard price of 4s. was fixed, with a sliding-scale as to dividends. A differential price of 6d. per 1000 cubic feet was allowed in the new area of supply authorized by the Cleethorpes Order.

Illuminating Power.

An illuminating power of 14 candles was prescribed in the Cleethorpes, Conisbrough, Elham Valley, Hatfield, Knottingley, Thurles, Tipperary, and Welwyn Orders; and in each case the "Metropolitan" No. 2 burner was prescribed as the test-burner. The illuminating power previously prescribed in respect of the Conisbrough undertaking was 15 candles, and in respect of the Knottingley undertaking 10 candles.

Special Provisions.

The Cambridge Order contains clauses providing for the disposal of stock and deposits under the co-partnership scheme instituted by the

undertakers in connection with their undertaking. A provision was inserted in the Elham Valley Order that the powers conferred by the Order should not be exercised until a company had been formed for the purpose of carrying on the undertaking. The Thurles Order contains an agreed clause relating to the purchase of the undertaking by the Thurles Urban District Council. In the Welwyn Order, provisions were inserted requiring the undertakers to lay certain mains within twelve months of the commencement of the Order, and providing that the powers conferred in respect of any parish should cease if after five years the undertakers were not affording a sufficient supply of gas in that parish. Clauses were inserted, by agreement, in various Orders for the protection of road and other authorities.

WATER ORDERS.

The principal objects of the applications for Water Orders were as follows:

Chiddingfold and District Water.—To empower the Chiddingfold and District Water Company, Limited, to maintain and continue existing water-works, construct and maintain further works, and supply water within the parishes of Dunsfold and Chiddingfold, and part of the parish of Witley, in the County of Surrey.

East Surrey Water.—To extend the limits of supply of the East Surrey Water Company, and to empower the Company to acquire lands by agreement.

Elham Valley Water.—To empower the Elham Valley Water Company, Limited, to raise additional capital.

Henley-on-Thames Water.—To extend the limits of supply of the Henley-on-Thames Water Company, Limited, and to empower the Company to acquire lands by agreement, and construct additional works.

Wimborne Minster Water.—To extend the limits of supply of the Wimborne Minster Water-Works Company, Limited.

The application from Chiddingfold and the district was in respect of an existing non-statutory undertaking. All the other applications related to undertakings already authorized by Special Acts or Provisional Orders.

Opposition.

Objections were lodged with the Board of Trade against all these applications except that of the Elham Valley Water Company, Limited. The Board held an inquiry and granted an Order in each case, subject to such modifications and amendments as seemed desirable. A considerable number of objections were made against the East Surrey application, and the inquiry in that case lasted for three days. As a result, the Board made substantial alterations in the rates chargeable by the promoters.

CONFIRMATION BILLS.

Bills to confirm the Orders granted were introduced as follows: In the House of Commons, the Gas and Water Provisional Orders Bill, to confirm Orders relating to Hatfield (Yorks.) Gas, Swansea Gas, West Kent Gas, and Elham Valley Water. In the House of Lords, the Gas Orders Confirmation (No. 1) Bill, to confirm Orders relating to Conisbrough Gas, Elham Valley Gas, Knottingley Gas, and Thurles Gas; the Gas Orders Confirmation (No. 2) Bill, to confirm Orders relating to Cambridge University and Town Gas, Cleethorpes Gas, Tipperary Gas, and Welwyn, Knebworth, and District Gas; and the Water Orders Confirmation Bill, to confirm Orders relating to Chiddingfold and District Water, East Surrey Water, Henley-on-Thames Water, and Wimborne Minster Water.

The Water Orders Confirmation Bill contained a clause repealing the powers of the Chelsham and Woldingham Water-Works Company, Limited, to supply water within a portion of their limits which, by agreement between the Company and the East Surrey Water Company, was included in the new limits of supply of the latter Company authorized by the East Surrey Water Order. The clause also repeals the powers of the South Oxfordshire Water and Gas Company to supply water within a portion of their limits which, by agreement between that Company and the Henley-on-Thames Water Company, Limited, was included within the new limits of supply of the latter Company authorized by the Henley-on-Thames Water Order.

Opposition in Parliament.

No Orders included in the Gas and Water Provisional Orders Bill were opposed in the House of Commons; but petitions were lodged in the House of Lords against the Swansea and West Kent Orders by the Alkali Manufacturers' Association. The petitioners asked that the undertakers of these Orders should be restricted from purchasing or using materials other than those required for the manufacture of gas or for working-up their own residual products. The Committee who considered the matter inserted a clause to this effect in both Orders.

A petition was lodged in the House of Lords against the Gas Orders Confirmation (No. 1) Bill in respect of the Knottingley Gas Order; but it was not supported before the Committee, and the Bill consequently became unopposed. On the motion for the third reading being made in the House of Commons, the Bill was recommitted for the purpose of giving effect to an arrangement arrived at between the promoters of the Thurles Gas Order and the Thurles Urban District Council, whereby the maximum price of gas fixed in that Order was reduced from 5s. 7d. to 5s. 4d. per 1000 cubic feet.

The Gas Orders Confirmation (No. 2) Bill was opposed in the House of Lords by the Tipperary Urban District Council in respect of the Tipperary Gas Order. An agreement was, however, come to in Committee, whereby the maximum price of gas was reduced from 5s. to 4s. 6d. per 1000 cubic feet, and a clause for the protection of the Council was inserted in the Order. A clause was also added to the Bill allowing the Council to borrow the money required to pay their costs in opposing the Order and the Tipperary Gas Bill, 1910.

Petitions were lodged in the House of Lords against the Water Orders Confirmation Bill in respect of the Chiddingfold and East Surrey Orders. With regard to the Chiddingfold Order, Mr. E. L. Rowcliffe asked that a clause should be inserted requiring the undertakers to afford a supply of water to those portions of his estate which were not included in the proposed limits under the Order. After hearing evidence, the Committee decided to insert the clause.

Opposition to the East Surrey Water Order.

Petitions against the Order applied for by the East Surrey Water Company were deposited by the Corporation of Croydon, the River Wandle Protection Association, the Croydon Rural District Council, and the Corporation of Reigate. The two first-named authorities complained that, though no further powers for the abstraction of water were conferred on the Company by the Order, the additional capital granted by the Order would enable the Company to provide further machinery of a powerful description, whereby the quantity of water pumped would be largely increased. They represented that, if more water were taken from the neighbourhood of Croydon, the supply by the Corporation would be seriously endangered, and the springs feeding the River Wandle would be depleted. After hearing evidence, the Committee inserted in the Order provisions limiting the total quantity of water to be abstracted by the Company in any year, by means of their pumping-stations and works at Purley and Kenley, to an average of 4 million gallons a day. The Corporation of Reigate and the Croydon Rural District Council objected to the revised rates for the supply of water authorized by the Order; but the Committee decided not to make any further amendment of the rates.

After the second reading of the Bill in the House of Commons, an instruction to the Committee to delete the Order was moved, but was rejected after debate. A further instruction was moved requiring the Committee to insert provisions prohibiting the Company from extending their pumping-stations, wells, adits, machinery, and other works for obtaining water at Kenley and Purley, and from constructing new works in connection therewith which would in any way detrimentally affect the Croydon Corporation's existing wells and works in that district. This motion was negatived without a division.

Both the Croydon Corporation and the River Wandle Protection Association lodged petitions against the Bill in the House of Commons; but the Committee to whom the Bill was referred did not make any amendment in the Order.

On the consideration stage of the Bill, an amendment was proposed requiring the Company to pay compensation for damage done by reason of their pumping operations; but the amendment was rejected. A motion to recommit the Bill to the former Committee, which was made on third reading, was also rejected.

Bills Royal Assented.

The Gas and Water Provisional Orders Bill received the Royal Assent on Aug. 7; the other three Bills, on Dec. 13.

LEGAL INTELLIGENCE.

THE GRAETZIN GAS-LAMP AGENCY.

German Law as to Agreements.

In the Commercial Court of the King's Bench Division last Friday, Mr. Justice Scrutton gave judgment in the action of *Braunstein v. Graetz*, in which plaintiff, Mr. Bernard Braunstein, a manufacturers' agent, of Carthusian Street, E.C., claimed damages from Mr. Max Graetz, the patentee of the Graetzin lamps, who trades in Berlin as Ehrich and Graetz, for breach of an agency agreement for the sale of gas and electric lamps and fittings in this country. The case was noticed in the "JOURNAL" last week (p. 197).

His LORDSHIP, in giving judgment, said that the plaintiff had for years been carrying on business in London for the sale of electric and gas lamps and fittings, and had for some time been acting as agent for the defendant under an agreement which provided that he was to have the sole agency for a term of years. In December, 1908, the defendant arranged with the plaintiff to take up the agency for his lamps and fittings upon an agreement under which, if he was able to sell £5000 worth of the Graetzin lamps within a year, the agency would be extended for another year, and if in the second year he was able to sell £10,000 worth, he was to have the exclusive right for a further period of five years. The business was very successful; and the plaintiff became entitled to the longer period of agency. In the last year of the contract, a large order was given by the Welsbach Company, in which they offered to sell 500,000 lamps on condition that no other firm in the United Kingdom should be supplied with the lamps at less than 5 per cent. above the price at which they were supplied. The Welsbach Company exceeded their amount in the first year of the arrangement, and in the second year they agreed to purchase 500,000 lamps to be marked with the Welsbach name. The plaintiff agreed to this, and the turnover again exceeded the order. For various reasons, the Welsbach orders were discontinued; and subsequently, with the plaintiff's consent, an agreement was entered into with Messrs. Krupka and Jacoby, under which they were to take a fixed amount of the goods. The plaintiff's agreement was affected by the arrangement; but it was compensated for by one with regard to the sale to other persons. It appeared that early in 1912 Messrs. Krupka and Jacoby's sales hardly reached the minimum for the first year; and, without the knowledge or consent of the plaintiff, an agreement was entered into by the defendant with the firm named for the whole of the electric lamp business, leaving the plaintiff with only the gas business, the agreement for which terminated in January of this year. By the agreement with Messrs. Krupka and Jacoby, a company was formed, and it was contemplated that they should deal with both branches of the defendant's business. Messrs. Krupka and Jacoby were to be Managing-Directors of the Company for a period of five years. The plaintiff was not told of this agreement, though letters were passing between him and the defendant relative to the business. He did not know what was being done until June of last year, when the defendant wrote to

Messrs. Krupka and Jacoby stating that the defendant was cancelling the agreement with them as from July, 1912. He (his Lordship) had considerable doubt as to the *bona fides* of this letter, which was not shown to the plaintiff until some time afterwards. The plaintiff had in the meantime been asking for new price lists, and he did not receive until the 26th of August the information that the defendant had arranged with Messrs. Krupka and Jacoby to give them an exclusive sale of the goods, and asking him not to obtain further orders. His Lordship continued to deal at considerable length with the bearing of the German law upon the question of agency agreements (it having been pleaded by the defendant that the plaintiff could not recover, as there was in German law no such thing as sole agency). Upon the authorities and upon the evidence, he was bound to come to the conclusion that, as the contract was made in Berlin, and the goods were supplied from that city, though the agency was carried on in England, it came within the German law, the interpretation of the contract was governed by German law, and the idea of an agency for the exclusive sale of goods was almost unknown in that law. Another point of importance was that when agents and principals disagreed as to the interpretation of a contract, the agent could not under the German law bring an action without having first obtained a declaration; and the agent, according to the expert evidence, could not complain of trading by other agents within his area. He (his Lordship) found that the second agreement was a breach of the plaintiff's rights so far as it excluded his action as agent in his district. He would have held that, under the English law, the defendant had no right to cancel the contract, and that Messrs. Krupka and Jacoby had no right to make the contract without plaintiff's consent; and he would have given judgment for the plaintiff on the claim, and assessed the damages at £2300. He held, however, that by German law the plaintiff was not entitled to damages, but was entitled to a declaration that the contract was a subsisting one. The plaintiff was not entitled, under the German law, to an exclusive right of sale in Great Britain and Ireland, but he was entitled to a commission of 5 per cent. on all goods sold in his district. The defendant was not entitled to exclude plaintiff from carrying on business in his district, or to prevent him from taking orders. With regard to costs, his Lordship said that, though the plaintiff had failed as to damages, he was entitled to a declaration and he would have half the taxed costs.

The form in which the judgment will be entered will be the subject of future discussion.

LIABILITY FOR A GAS WATER-HEATER ACCIDENT.

In the King's Bench Division of the High Court of Justice last Wednesday, Mr. Justice RIDLEY and Mr. Justice LUSH had before them the case of *Juler v. Tunbridge Wells Gas Company*. It was an appeal by the plaintiff from a decision of his Honour Judge Parry and a Special Jury at the Tunbridge Wells County Court in July last, as reported in the "JOURNAL" for the 30th of that month (p. 337).

Mr. SIMEY appeared for the appellant; Mr. HOLMAN GREGORY, K.C., and Mr. HARKER represented the respondents.

The appellant claimed £50 for damages to goods and for personal injuries sustained by her through the bursting, during a severe frost, of a gas water-heater or boiler supplied by the Company. It was agreed that the pipes leading to the boiler had became frozen, and that the gas had not been kept alight to prevent this; and the question to be decided was whether the Company had guaranteed that the boiler was safe, in terms which would cover their responsibility in a case of explosion caused by a frozen pipe. In the Court below, a verdict was entered for the Company.

Mr. SIMEY submitted that the guarantee of the Company's servant, that the boiler was safe, was quite sufficient to enable the plaintiff to recover damages against the defendants. The plaintiff was very nervous about the boiler, and asked if it was safe. She was told by defendants' agent that it was; but the explosion which took place was the very danger against which she was anxious to be protected.

Mr. GREGORY said the only guarantee that was given was limited to the expression that the boiler must be used as an ordinary kitchen boiler; and everyone knew that in such a case the water must be kept in the pipes to prevent explosion.

Mr. SIMEY said the guarantee given to the appellant was that the boiler would be safe under all circumstances.

Mr. Justice LUSH remarked that one of the Company's witnesses said he knew the boiler would be dangerous in case of frost.

Mr. HARKER said the appellant was told that if she kept the pipes clear of frost, no harm could be done. The lady was some forty-five or fifty years of age, and could not be held to be totally ignorant of the dangers existing in these cases.

Mr. Justice RIDLEY said the case was one of some difficulty, and the learned County Court Judge himself had said he was not satisfied with the verdict, though he did not think that the Jury could, by a reasonable train of thought, not have found as they did. He himself doubted if the finding was so unsatisfactory that there ought to be a new trial; but Mr. Justice Lush took a stronger view, and he (his Lordship) was not prepared to hold out against it. He thought at the new trial the Jury ought to be asked what was the guarantee the Company really did give. The order would be for a new trial, the costs to abide the result.

Mr. Justice LUSH agreed.

A new trial was accordingly ordered. Leave was given to appeal; and it was agreed that the new trial, if one was eventually necessary, should take place in a London County Court.

The Charge against a Former Gas Company's Secretary.

At the Bow Street Police Court last Friday, Robert Henry Rushforth, Solicitor and Clerk to the Justices at Amersham, was charged, on remand, before Mr. Curtis Bennett, with forging and uttering receipts and with committing perjury. The defendant, it may be remembered, was the Liquidator of the Amersham Gas Company, and it was alleged that he produced forged receipts in the names of shareholders who had not been paid at the time represented, though they afterwards obtained what was due to them. The alleged perjury was contained in two affidavits prisoner had sworn as to the money he had in hand and the shareholders he had paid on a certain date. The previous proceedings have been reported in the "JOURNAL." His Worship said he proposed to commit the prisoner for trial on charges of forging and uttering four receipts and committing perjury in two affidavits. Prisoner said he reserved his defence, and did not call any witnesses; but at the trial he proposed to give an explanation of his conduct. The case was formally remanded for a fortnight in order that it might go over to the March session of the Central Criminal Court; the same bail as before being allowed.

CORRESPONDENCE.

[We are not responsible for opinions expressed by Correspondents.]

Public Health (Acquisition of Water) Bill and the Water Supply of Rural Districts.

SIR,—In the House of Commons on the 20th inst., the Prime Minister, in reply to a question, announced the impossibility of the above-named Bill becoming law in the present session. The purpose of the Bill was to enable Rural District Councils to purchase "water rights" in streams compulsorily. At the present time, these Councils cannot legally promote Private Bills at all, and their powers as regards compulsory purchase are confined to land. This they can acquire under Provisional Orders granted by the Local Government Board and confirmed by Parliament under the provisions of the Public Health Act, 1875. Though the purchase of land includes the acquisition of landowners' rights in "underground water" not flowing in a defined channel, it does not include the compulsory acquisition of "water rights" in surface supplies, or in water which flows off the land on to adjoining and other property below the site purchased. "Water rights" of this character can only be acquired compulsorily by a Private Act of Parliament; and as Rural Councils have no power to promote Private Bills (except at the risk of being surcharged with the costs if the Bill is not passed), it is impossible for them in many cases to discharge their duty of providing proper water supplies to their districts.

The Bill referred to was of great importance and value, inasmuch as it would have enabled these Councils, by Provisional Order from the Local Government Board, to acquire compulsorily water supplies as well as land. The surface supplies in question can rarely be acquired by agreement, as there are usually a very large number of riparian owners to be settled with, and a refusal to treat with any one of these is fatal to the whole scheme.

At the present time, I am acting for a Rural Council where the conditions afford a striking example of the difficulty referred to. Here it is desired to acquire some springs for the supply of a district extending to an area of over 100 square miles, and where no other equally suitable supply is available. One of the 42 riparian owners interested in the stream flowing from these springs has refused to treat for the acquisition of his interest, and consequently the whole scheme has to be abandoned, at any rate temporarily. The Public Health (Acquisition of Water) Bill was promoted by the Local Government Board to meet cases of this sort; and it is a serious matter to many Rural Councils, and particularly the one I have mentioned above, that this most useful measure should be held over because the attention of the House is fully engaged in passing political measures the advantages of which are strongly disputed by a large section of the members. Surely a question of public health should take precedence of purely political measures.

The case for the proposed Bill could be supported by many arguments of a more technical nature than those given above; but I have confined myself to the broad question of public interest which I think will be appreciated by a large section of your readers.

PERCY GRIFFITH, M.Inst.C.E., &c.,
Secretary, Institution of Water Engineers.

20, *Victoria Street, Westminster, S.W., Jan.* 24, 1913.

Biddulph Gas-Works Purchase.—A meeting of ratepayers has been held for the purpose of considering a resolution regarding the proposed purchase of the local gas-works by the Biddulph Urban District Council; but after speeches had been made both for and against the scheme, a large majority voted against the resolution, which was in the following terms: "That this body of ratepayers beg to protest against the proposed purchase of the Biddulph Gas-Works by the Urban District Council; and that a copy of this resolution, together with the grounds for such protest, be sent to the Local Government Board, and also to the Clerk of the Council."

Automatic Lighting in Liverpool.—When the Lighting Committee's estimates came before the Liverpool City Council, Mr. Hughes said they were told, when automatic gas lighting was introduced, that they were to have something like £5000 or £10,000 a year saving in the consumption of gas; but he saw there was only a difference of £500 in the estimate this year. The Chairman (Sir Charles Petrie) pointed out that there was a recommendation brought up by the Lighting Committee that they should spend £35,000 on automatic lighting. This meant that practically the whole of the employees would be dismissed at one time. He dissented from this, and they had been extending the introduction of the automatic lighting over a certain number of years, so that they would not displace any of the men. But as they died or found other employment, they were not replaced. At the end of a few years, the whole of the city would be automatically lighted, which would provide the saving foreshadowed. The saving would be in labour, and will amount to £5000 a year. There would be no reduction in gas consumption.

MISCELLANEOUS NEWS.

SIDMOUTH GAS-WORKS PURCHASE ARBITRATION.

The Urban District Council's Case.

A report is given to-day of the second portion of the proceedings, at the Surveyors' Institution, Great George Street, S.W., in the arbitration to fix the price to be paid by the Sidmouth Urban District Council for the undertaking of the Sidmouth Gas and Electricity Company. The hearing extended over four days; Thursday and nearly the whole of Friday, Jan. 16 and 17, being occupied with the Company's case [a report of which appeared on pp. 198-201 of last week's issue], and Saturday and Tuesday, Jan. 18 and 21, with the evidence for the Council and the speeches.

Mr. A. J. RAM, K.C., acted as Umpire; and there were with him as Arbitrators Sir CORBET WOODALL, D.Sc., for the Company and Mr. C. C. HUTCHINSON, K.C., for the Council.

The Counsel appearing were Mr. G. M. FREEMAN, K.C., and Mr. W. J. JEEVES (instructed by Messrs. Torr and Co.) for the Company, and the Hon. J. D. FITZGERALD, K.C. (instructed by Messrs. Baker and Co.), for the Council.

Second Day (*continued*).

ARGUMENTS FOR THE COUNCIL.

Mr. FITZGERALD said that, though he intended to reserve his remarks on the facts until the end of the case, certain questions of law arose about which he would like to address the tribunal at once. The transfer in this case was not in the ordinary form. The common form was that the selling company took all the receipts on revenue account and paid all the outgoings; while mortgages and debentures were left as a charge on the undertaking and taken over by the purchaser. Under section 6 of the Council's Act of 1912 it was provided that, in addition to the purchase price, the Council should pay all the taxed costs of the Company for obtaining the 1911 Act and of the transfer of the undertaking and the winding-up of the Company. Sub-section 4 said: "The Company shall be entitled to retain, or shall be paid by the Council in addition to the price or consideration for the transfer of the undertaking, such sum as shall be necessary to enable the Company to pay dividends at the authorized rates from the date of the last payment of such dividends to the date of transfer; but subject to the payment of the said dividends, the Council shall upon the transfer be entitled to the benefit of all revenues, receipts, and profits from the undertaking of the Company down to the date of transfer." Section 8 said: "All obligations and liabilities of the Company (other than mortgage or debenture debts and the interest thereon which shall be paid by the Company) which exist at the date of transfer . . . shall be satisfied by the Council." The effect of this was that the Company were to retain the liability as to the debenture and mortgage debts. Out of these points, four matters arose which might be considered partly questions of law. First, the position of the preference shareholders; secondly, the position of the debenture holders; thirdly, the fact that the payment of the dividend of 16 per cent. in December, 1911, was then made in the name of back-dividends, and that for this purpose the reserve fund was appropriated; and, lastly, there was the question of the costs, which the Council were liable to pay, and which the Company were trying to get twice over. As to the first point, under section 26 of the 1911 Act, which was a reproduction of one of the Limited Company's Articles of Association, it was stipulated that in the event of winding-up the holders of preference shares should be repaid the amount paid up thereon before any sum was repaid to the holders of ordinary shares, but that the preference shareholders should not be entitled to any further participation in the assets. In the valuations put forward, this provision had been ignored altogether. The dividends on the preference shares had been capitalized at 28½ years' purchase, or 33⅓ taking the 10 per cent. added, and so had brought the shares out to something far above par value. If this were allowed, the effect would be that the preference shareholders would get the par value of their shares, and the surplus would be handed over to the ordinary shareholders—forgetting that the latter were limited in respect of their dividend. He could not understand how such a claim, as a matter of law, could be substantiated. The amount of the dividend was not the basis of compensation here, because the preference shareholder had contracted to take his dividend on the basis that in a winding-up he should get the par value of his shares. The governing principle of the case was that the tribunal should only compensate for what was lost by the seller.

Third Day.

Mr. FITZGERALD resumed his opening remarks, and dealt first with the question of the debentures, which he said, on the winding-up, became immediately payable at par. It was perfectly true to say that the holder of the 6 per cent. debenture, being paid off at par, would lose an extra 1 per cent., as opposed to what he would get if the money were invested in a similar security. He would lose this for 2½ years; and that would be exactly £50. If this claim could be put forward, this would be the limit of the loss. But he was unable to find that any such claim on behalf of a debenture holder had ever been sustained. As to the 4½ per cent. debentures, he did not see how a claim could be put forward for them, because it was practically admitted that the holders, if paid off at par, could re-invest their money in other gas companies' debentures at 5 per cent. Therefore, so far from being damaged by being paid off at par, they were actually getting more than the market value. So the whole of this claim disappeared, with the exception of a possible £50; and in support of even this, there was no authority at all, so far as he had been able to discover. In the case of a large number of debentures in limited companies, there was a provision put in that the debenture became immediately payable on a winding-up. This was inserted for the advantage of the debenture holder, to prevent any question arising; and it appeared that the provision in section 14 of the Act was practically the same. The next point was the payment of 16 per cent. in December, 1911, by way of back-dividend; and in connection with this, he argued that the amount placed to the reserve fund could not be taken away again, and paid as dividend, though sums could be taken from the reserve fund to make up a deficiency that might arise in any year afterwards in the profits of the Company. As the result of an alteration made in the Bill after it had passed the House of Lords, the Limited Company, instead of being dissolved immediately after the passing of the Act, would remain in existence until Jan. 1, 1912; and in December, 1911, it seemed to have occurred to somebody that they might pay this back-dividend, so a very short time before the Company ceased to exist they proceeded to pay a dividend of 16 per cent. This they could only do by appropriating the reserve fund for the purpose; and that was wholly illegal.

Mr. FREEMAN: We could have done it without taking any money from the reserve. I do not admit my learned friend's contention.

Mr. FITZGERALD: Any way, they did appropriate the reserve fund for the purpose; and, further, they declared a dividend of 16 per cent. on the £3500 of ordinary shares issued in 1909, 1910, and 1911. Part of these had only just been paid up; and the holders of these shares received 26 per cent. dividend.

Mr. FREEMAN: The shares were given to people who also owned the other shares.

Mr. FITZGERALD: I think it is things being done in this way that, in this spirit of greed, brings an undeserved slur on the gas industry as a whole. I do not believe any company of standing would resort to such an arrangement as this, after what had taken place before the House of Lords, whether it was legal or not. But I hold it is absolutely illegal, and they have no right whatever to appropriate this fund. The whole of this sum should be a deduction from the purchase money.

QUESTIONS ON THE ACCOUNTS.

Mr. *W. B. Keen* was the first witness for the Council, and, in answer to Mr. FITZGERALD, he said that he had, in conjunction with Mr. Cash, prepared the set of tables which had already been put in. If the Company had not paid the £2450 for the costs of the Act, the bank overdraft would have been less by this amount; and so if this sum had to be paid by the Council, and if they also paid the overdraft, they would be paying the costs twice over.

In cross-examination by Mr. FREEMAN, witness said that if the money was put aside as a contingency fund, it might be doubtful whether the provisions of the Act dealing with reserve funds would apply to it.

Mr. FITZGERALD: In the report for 1910, the Directors recommended that a sum of £800 should be put to the reserve fund.

Mr. FREEMAN pointed out that the Consols were sold on April 27, 1912—three months after the payment of the dividend. After the Company had paid current dividends and the back-dividend, they were still £926 to the good.

Witness: No; the balance-sheet at Sept. 30, 1911, at the time when they had the £926 undistributed profit, showed that they had a bank overdraft of £48, and cash in hand £27 only. So that the net money was a *minus* quantity of £21.

Mr. FREEMAN: That is after taking into consideration a large payment on account of the Act.

Witness: They paid the dividend by means of a bank overdraft, and subsequently reduced this overdraft by the sale of the Consols.

Mr. HUTCHINSON: At the date the money was actually paid, could they have paid it in money by way of back-dividends unless they had appropriated the reserve fund or sold some other property of the Company?

Witness: Or borrowed from the bank. They could not.

The UMPIRE asked whether the Company could have dealt with the £800 in any other way than by putting it to a reserve or suspense account.

Witness replied that they could have carried it forward.

Sir CORBET WOODALL: And then no question of this sort would have arisen. It has been suggested that the reserve fund was sold out to pay back-dividends. Is there anything to show that the Consols were sold for any specific purpose?

Witness: I think the inference is quite clear from the audited accounts of the Company.

VALUATIONS FOR THE COUNCIL.

Mr. *E. H. Stevenson*, in answer to Mr. FITZGERALD, stated that he had inspected the works and the district of supply. The works were in very fair condition, and were of sufficient capacity for the present demands, but not for much more. When he first inspected them, in connection with the opposition to the Company's Bill, he gave to each part of the works the capacity which he thought it was equal to, without referring the matter to the Manager; but when he went down the second time, he did make inquiry of Mr. Appleyard as to what he could manufacture in the retort-house, and he said distinctly that he had made about 5700 cubic feet per mouthpiece for a very short period, but that he considered 5000 cubic feet very good indeed, and was satisfied even with 4500 cubic feet. At first he thought that they were all regenerators; but there was only one regenerator, while two were generators and the other one was a direct-fired furnace. The maximum day's make was now 98,000 cubic feet; and the carbonizing plant—that was, the three settings of retorts—on Mr. Appleyard's basis of very good working was 105,000 feet, which was only a surplus of 7000 feet. This was practically negligible, and would probably be overtaken by the time the Council got hold of the works. The scrubber had a slight margin over the present make; and the purifiers were equal to 80,000 cubic feet a day. The storage was about equal to a maximum day's output, and was sufficient for the present. As to the mains, about 20 per cent. were 2-inch and 51 per cent. 3-inch. Further than this, some of the small mains were continued by mains of larger capacity. There was no doubt that the mains were too small. Mr. Brearley had given the pressures at various times. Now, the difference of pressure between the works and Sidford, at 11 p.m., when there was practically no gas being consumed, was shown as 13-10ths. The pressure was 13-10ths higher at Sidford than

at the works. At 5 p.m., however, when there was a considerable consumption, the pressure was 5-10ths less at Sidford than at the works. Thus there was a fall of static pressure in the pipes of nearly 2 inches—and with very little consumption at Sidford, which was practically the end of the main. It would be necessary to replace a great many of these small mains, even if there was not an increase in consumption, in order to reduce the pressure. The pressure they now had to give must increase the leakage. Very few consumers, so far as he was aware, had governors in their houses, though they ought to have—especially with the high pressures used nowadays.

Sir CORBET WOODALL: Do you regard this as a high pressure?

Witness: I do, in a small works like this, consider it a high pressure to start at nearly 4 inches. I can understand large towns, where they have to send the gas long distances.

Further examined, witness said he had made a structural valuation; but generally speaking he was not very far different from Mr. Woodall, except upon the valuation of spare lands, and so on. His total was between £19,500 and £20,000, including land and buildings not at present used for gas-works purposes; and this was just about the amount expended. It showed really that the money spent was there. The public lighting was on the average meter system; and he thought the amount the Council had been called upon to pay was in excess of the quantity of gas that should have been consumed. Analyzing the accounts for four years, he found that the consumption per hour of the different types of burners varied very much. The contract was that the lamps should be lit one hour after sunset, and continue burning until 11 p.m. From calculations he had made, he reckoned that this overcharge amounted to about £90 per annum. So far as he could see, there was nothing in the accounts to explain the great drop in leakage. As to the increase in the make of gas last year, he knew of no alteration in the coal to account for this. His experience was that there was no possibility of making 10,847 cubic feet of gas per ton from Somersetshire coal, with the apparatus that the Company had. The average of all the companies in Somersetshire was only 9934 cubic feet; and this included a company who only used one-third of Somersetshire coal and the remainder Yorkshire or North Wales. If this one was omitted, the average make was 9829 cubic feet. Three of the companies had water-gas plant, so that they could reduce the quality and make a larger quantity of gas per ton, and then increase the quality by means of the carburetted water gas. The coke, tar, and ammonia all pointed to the same thing. With the same settings, they in 1912 used 33 per cent. less coke for firing; and they made more tar and more sulphate of ammonia, as well as more gas, per ton of coal. What all these things pointed to was that at the end of 1912 they had taken the stocks of coal very accurately, while in previous years they had not done it so accurately. The general rule in gas-works was that the actual stock of coal was more than the nominal stock, so as to have a little in hand, to allow for getting in a parcel of bad coal during the year. The quantity of coal stated to have been carbonized in 1912 was 2125 tons; and to this he thought 154 tons ought to be added. As shown, the price of coal diminished every year, until in 1912 it was 17s. 3d. He had, however, looked into the coal contracts which had been produced, and found this figure represented the price under contracts in 1911. If he had taken the price under the contracts of 1912, it would average 2s. 1½d. per ton more. For the year 1913, the price was still higher. Therefore in arriving at the net maintainable value, an addition had to be made to the price of coal for 1912; and this addition ought to be at least 2s. 6d. per ton. During about six months of 1912 the price of residuals was very much increased in consequence of the rise in the price of coal. The amount charged for repairs, maintenance, and renewals in a place like Sidmouth ought to be 6·5d. per 1000 cubic feet. The figure of 5·05d. named for 1912 was not the sum spent on repairs and maintenance, because there was 0·59d. for depreciation of stoves; so that the actual amount spent for repairs, &c., was 4·46d. The difference between 4·46d. and 6·5d. was 2·04d. per 1000 cubic feet; and if this had been expended, it would have meant an extra £180.

Witness then proceeded to explain his valuation, which he said he started, like the others, by taking the profit shown on the revenue account for the year to Sept. 30, 1912 (£2314); and the first deduction he made was £31 for charge in excess of the standard price of 4s. The next was the charge made in excess of the proper estimated quantity of gas consumed by the public lamps, £90; and the third was the deficiency in the quantity of coal—154 tons at 17s. 3d., or £133. Then there was the increase in the price of coal of 2s. 6d. for 2279 tons, which meant £285; and the profit on fittings (£29), which he had eliminated because it was not a profit which a gas company could be certain of. At three years' purchase, however, if allowed, the latter item would only come to £90. Then his last deduction was the deficiency on repairs and maintenance already explained, which equalled £180, and brought his total deductions to £748, and made the maintainable income £1566. The amount required to pay interest and the standard rate of dividend was £1515, showing a surplus profit of £51. The multiplier he used was 20 years, which he applied to the £900 dividend on the ordinary shares; and this gave £18,000 for the £9000 worth of these shares, which was equivalent to £20 a share. In the circumstances of the case, he regarded 20 years as generous. He gave consideration to the fact that the Company had undertaken to provide electricity, which was a very risky thing for a small company. There was no probability of an electricity undertaking in a small town like this being remunerative. His total valuation came to £29,000, adding £11,000 for the preference and debenture capital. From this he deducted, as paid in respect of back-dividends and income-tax, £1730, bringing out the net valuation of the undertaking at £27,270. The Company distinctly led the House of Lords Committee to understand that they were not going to claim these back-dividends.

Cross-examined by Mr. FREEMAN, witness maintained that, apart from any questions of complaint, he would advise the relaying of the small mains, even though no increased consumption was contemplated. If he had the management of the works, he believed the output could be doubled in a comparatively few years—about seven or eight years. The figures of pressures to which he had drawn attention were of tests taken on different days; but this would not affect the result. When it was found that the prices charged for public lighting were too high, certain of the burners were taken off and sent to Messrs. Willey and Co. to be tested for consumption per hour. With regard to the make of gas, he did not suggest that the tables put in by the Company had been falsified in any way. The results had been obtained by the stocks being taken accurately now, and in past times the stocks having a surplus. He admitted that 20 years was not the figure he usually took, and said if this had been purely a gas undertaking (without the electricity provisions), he would have given more. In fact, he did not think he had ever given 20 years before, but he had never had to deal with a company who had to put up an electricity installation. Had it not been for the electricity clauses, he would have suggested 22¼ years. The dividends then would have been fairly well secured, but with not much balance in hand. When acting for a local authority, he left the question of the 10 per cent. for compulsory purchase entirely to the tribunal.

Sir CORBET WOODALL: Do you regard the price of coal as shown for last year, *plus* the 2s. 6d. you have put on, as the normal price?

Witness: I am very much afraid that we shall get no reduction from last year.

Though it is considerably above the normal or average price of coal over a term of years?—It is considerably beyond the average of recent years, I admit; but I think everything tends to increase the price of coal permanently. The prices of last year are more or less normal.

And upon the strength of that you make a reduction of how much?—Of £285 a year.

The UMPIRE: If there was no necessity for knocking off this figure, you would, of course, get the surplus profit increased by that amount. There should be added £285 to the £55. Would the amount of what is really maintainable profit depend upon whether you are right or wrong in your belief that we must regard last year's price of coal as normal?

Witness: Oh, certainly.

Mr. *Frank Jones*, examined by Mr. FITZGERALD, agreed that generally speaking the works were in fair order, and just about capable of the present output. As to the mains, they were smaller than he would like to see in any district, because they were expensive to maintain. Of course, they had supplied the gas, and could go on supplying it. Different people had different views as to pressure, but personally he thought that there was not, on the whole, much wrong with the diagram put in. The amount spent on repairs in the account year was much lower than it should have been. No company, however small, should spend less than 9d. per 1000 cubic feet. Of this 9d., probably 2d. or 2½d. would be for depreciation. The difference between what was expended and what he considered necessary was £336. The present price of 4s. per 1000 cubic feet might in the near future be reduced 1d. or 2d., but certainly not to any very material extent. With the present price of coal, he did not think the charge would be reduced very soon. A certain amount of income had been got from the prepayment consumers which was not justified by the rates authorized. The net figure for coal—which dropped to 4s. 8d. last year—was extraordinarily low. He was familiar with Somersetshire coal, and could not see anything in the tables put in to induce him to think that the figure of 10,847 cubic feet per ton was correct. He could not accept it at all. He gave the works credit for making 10,300 feet, which was the most the Epsom Gas Company (with which he was connected) could get out of such coal, with all its modern plant—the gas being of about 14 candles, and 9 cwt. of surplus coke. The conclusion he came to was that a mistake had been made somewhere in the coal stocks.

Witness then submitted his valuation. Beginning with a profit of £2311, he deducted the difference for repairs, as already explained, £336; the excess charge made for gas, £31; and the overcharge for public lamps, £90. Then there was the additional cost of coal, at 2s. 6d. on 2238 tons, £279. From his knowledge of other companies, the price of coal was certainly during this winter 2s. 6d. higher than a year or two ago. In the future he thought it might be more. Then he had struck out the profit on the fittings. Something should be allowed, but only a small amount. He did not agree with a company making a profit out of fittings; but as this Company had done it, they should be allowed a little. Lastly, he deducted £97 for coal from store. He had adjusted the figures of 10,300 cubic feet per ton and the Company's 10,847 feet; and the extra coal must have come from somewhere. This made the sum to be deducted £862, leaving the income at £1449. This showed that the income was not equal to the charges on it by £66; but he took the amount they divided, and capitalized the dividend on the ordinary shares at 20 years' purchase. He had arrived at this figure by seeing whether there was a surplus as regarded works, whether or not the mains were in good order, and whether the business was stable. This was a good little business. He said it was a 5 per cent. investment, and quoted recent instances of gas debentures being sold to return this rate of interest. His valuation was £29,000; and deducting from this the £1730 for back-dividends, there was left £27,270. He had made a structural valuation which practically agreed with that of Mr. Woodall.

In cross-examination by Mr. FREEMAN, witness said that the number of years' purchase depended upon the maintainability of the income and the value of money. The works had a safe margin beyond their present requirements, and a growing business which had considerable capacity for increase. Generally speaking, he attributed some importance to the question whether a company was statutory or non-statutory. He did not suggest that the accounts had been improperly prepared; but they had spent very little on repairs. The mains were disgraceful, though the manufacturing works were in very good repair. The mains were sufficient to supply the present demand; but 2 and 3 inch mains in a bad soil, such as he believed it to be, would need more for up-keep than larger ones. The leakage in the past showed that they were in a bad condition. These little mains broke much more easily; and when a service was put in, they were cut half through. That there must have been some mistake in the coal storage, he felt confident.

Mr. FITZGERALD (in re-examination): When taking the number of years' purchase, you have to look at the value of money; and when Consols stood at 114, and were worth 45 years' purchase, the value of money and of gas stocks was far different from what it is to-day. Now Consols have fallen to about 75, which is 30 years' purchase. There has been a fall of 15 years' purchase in Consols in the last fourteen

years. Similarly, there has been a fall in the value of all high-class securities; and looking at the prices to-day, does 20 years' purchase represent the full value of the dividends on these shares?

Witness: You can invest money to-day in good gas companies to pay you over 5 per cent.

The UMPIRE: Part of your evidence was directed to the working expenses and the small amount that has been expended. Among these, of course, are the repairs to mains. The leakage was very large up to the year 1909. Since that year it has been very much improved, and the unaccounted-for gas has gone down from 16·97 per cent. to 7·85 per cent. This is a very material improvement. Can you tell us of anything except expenditure on mains to explain this?

Witness: I think the leaks have been stopped, undoubtedly.

FURTHER EVIDENCE.

Mr. *Charles Chapman*, Manager of the lamp and burner department of Messrs. Willey and Co., gave evidence as to testing certain burners from the public lamps which were sent to his firm by the Council. Some of the self-intensifying burners he was unable to verify, as the gas-adjusters had apparently been unintentionally altered in taking them off the lamps. He produced figures showing the results of the tests made by him.

Mr. *Richard Lake*, Surveyor to the Council, spoke to taking the burners to Exeter to be tested. He did not suggest to Mr. Appleyard that he should go with him to have the tests made.

Mr. *J. G. H. Halse*, a member of the Council, said there had been complaints about various things in regard to the public lighting. Some had reference to the accounts; and there was the special matter that these burners were tested for. The overcharge was discovered in consequence of the coal strike, when the Council had the gas turned out altogether for some days; and when the quarterly account came in, it was felt there should have been a reduction. The amount, however, was only a few pounds short of what it ordinarily was. He then raised the question of the consumption per hour of the different burners, and found an extraordinary difference between the number of cubic feet charged for and the stated consumption of the burners. Sometimes the lamps had been lighted a great deal before they ought to have been.

Fourth Day.

Mr. *Charles E. Baker*, whose firm acted as Parliamentary Agents for the Council throughout the proceedings in opposition to the Company's Bill of 1911 and in the promotion of the Council's Bill of 1912, was called and examined with reference to the negotiations that took place between the parties. With regard to the Company's Bill, he said that after the measure had passed through the House of Lords, negotiations were entered into for the withdrawal of the opposition of the Council and the insertion of a purchase clause. Such a clause was drawn up and submitted to Messrs. Torr and Co., the Agents for the other side, who suggested certain alterations, one of which was that the Umpire or Arbitrator should add to the sum awarded 10 per cent. for compulsory purchase. This the Council declined to accept; and Messrs. Torr agreed that the provision should be struck out.

Mr. FREEMAN: It was asked that it should be an obligation to the tribunal that they should add 10 per cent. You, on your side, proposed that it should be an obligation on the tribunal that they should allow 1 per cent. In the original draft you returned to Messrs. Torr and Co., the "10" was struck out, and "1" inserted over it—for "cost of re-investment," instead of for "compulsory purchase." There being the 10 per cent. proposed on one side, and 1 per cent. on the other, it was agreed to strike both out, and leave the matter to the tribunal?

Witness replied that this did not agree with his recollection.

Mr. FREEMAN thereupon asked permission to call

Mr. *C. H. W. Johnson*, of Messrs. Torr and Co., who had charge of the Bill on behalf of the Company. Witness said that the clause was originally returned to Messrs. Baker with an addition stipulating for the allowance of 10 per cent., and they returned it altered from "10" to "1." He again returned the clause with the "1" struck out. The Company were willing to give up the obligation. There was no dispute on the facts; the only question was the effect of the arrangement. The whole question was dropped, and the matter left to the tribunal.

THE CASE FOR THE COUNCIL.

Mr. FITZGERALD said that, before he dealt with the valuations, there were two questions requiring to be noticed. The first was with regard to the cost of the Act. The Council had to pay the cost of the Act once, but not twice over, which was what the Company had ingeniously arranged. The Company had already paid the costs themselves, by borrowing money from the bank to do it.

Mr. FREEMAN remarked that there was evidently some misunderstanding. It was not the Company's intention that the Council should pay twice. They could choose whether they would pay for the Act or the bank overdraft. So far as it could be proved that any portion of the overdraft related to the cost of the Act, the Council should not pay it. The main portion of the amount, however, had nothing to do with this.

A consultation on the matter took place between Counsel, after which

Mr. FITZGERALD said he thought that before the close of the case they would be able to settle this point. Continuing, he argued with reference to the 10 per cent. for compulsory purchase, that the upshot of the negotiations was that a bargain was clinched by the withdrawal of the claim for this. He did not believe that, in recent years at any rate, 10 per cent. had ever been allowed in connection with the sale of a gas-works. If the shareholders got full value, and the costs of the Act and winding-up, this was all they were entitled to. The only other item was the cost of re-investment, because no loss of interest need occur. In the valuation there were two figures to be found by the tribunal—the multiplicand and the multiplier. But in arriving at the former there were numerous items to be taken into account; and this was what caused a little trouble in these cases. Taking Mr. Brearley's valuation, the first addition made was £19 for restriction in public lighting. There was no reason whatever for this. It was because during the coal strike the Council reduced the public lighting. Though Mr. Appleyard denied he made the statement that the Company had only three weeks' supply of coal to start with, he did not deny that it was a fact. The Council acted as they did out of consideration for the Company—and also, of course, in the general interests of the town. The next addition was £50 for increased rents of property in the hands of the Company. These rents, however, had never been received by the Company, and, further than that, the actual rental which they had been getting was a decreasing one. They were dealing with the case of a Company the Directors of which had bought certain lands not now used for gas manufacturing, with a view to the improvement of the undertaking; and this being so, it appeared to him that the point only came in when they were considering whether the property of the Company, including the works and land, represented fully the amount sunk in the undertaking. The profit on fittings—for the £29 on account of which Mr. Brearley made no deduction—when they were dealing with a gas undertaking, only properly came into consideration at all where the Company were not paying their full dividend. Then the ordinary practice was to capitalize the profit on fittings at about three years' purchase. Where, however, a company were getting their full amount of dividend, he did not see how the profit made on gas-fittings could come in. It was, however, a small matter here, and if capitalized at three years' purchase would only amount to about £90. The next item in Mr. Brearley's valuation did not appear in Mr. Woodall's valuation at all. It was for increased sales of gas during the current year, £125. Just see what Mr. Brearley was doing here. He was asking them to add to the year of account an assumed income of £125, which he said would be earned in the next year. He arrived at it by assuming that there would be an increased sale of gas of 5 per cent. over the present year; whereas, in fact, the increase in sales in the past year was only 2·95 per cent., and there was no evidence at all that there had been any increase in the year beginning last October, one quarter of which had already expired. This sum, of course, the witness capitalized at 28½ years' purchase, and added 10 per cent. for being disturbed in the enjoyment of an income which they never possessed. Taking the two sums together, the compensation for the assumed income of £125 would work out to very nearly £4000. The whole of this ought to be struck out. The next item in the valuation was a very peculiar one. Mr. Brearley took the £5000 of debentures, and did not deduct the actual interest being paid on them, but assumed instead 3½ per cent. And he did this in the face of the evidence of Mr. Henry Woodall (who spoke with considerable knowledge), that if this Company went into the market to borrow money they would probably have to pay about 5 per cent. Then Mr. Brearley concluded that the Company could have reduced the price of gas in the account year from 4s. to 3s. 4d. per 1000 cubic feet, and therefore earn an extra dividend of £180, to be capitalized at 28½ years. This standard price of 4s. was fixed in 1911; and of the two witnesses on behalf of the Company at that time, one said 4s. 5d. and the other 4s. 2d. would be a fair standard price. It was impossible that either of these gentlemen could have given such evidence if they had believed that in 1912 the Company would have been able to reduce the price to 3s. 4d., and at the same time to pay the full standard dividend of 12 per cent. The basis of the standard dividend was a price which would produce enough, if the undertaking was fairly and economically worked, to pay the standard dividend. In fact, the Committee of the House of Lords fixed the price at 4s., in face of this evidence. This additional income of £180 put on to the valuation about £5500. It was not necessary for him to go through Mr. Woodall's valuation; but he would point out that in neither valuation had any deduction been made for the increased price of coal (though Mr. Woodall quite fairly admitted that some allowance ought to be made), nor had any deduction been made for the insufficient sum spent upon repairs and maintenance. Turning to the valuations on the other side, Mr. Stevenson had dealt with the consumption of the burners on the public lamps—the contract for which was on the average meter system. The lighting had probably been longer than was stipulated for in the contract, and thus a larger quantity of gas was consumed; and when taken on the proper hours, this showed an increased consumption over the real consumption per hour of the burners. On the evidence, it was quite clear that there had been an overcharge, and a deduction of £90 did not appear excessive. The next item of Mr. Stevenson was for deficiency in coal. No explanation whatever had been given by the Company of the extraordinary rise in the yield of gas.

Sir CORBET WOODALL: The Manager did say his coal had been in better condition.

Mr. FITZGERALD: He said there had been no substantial difference in the coal between 1911 and 1912.

Sir CORBET WOODALL: Except that it might have been sent in better condition—better cleaned, and less small coal.

Mr. FITZGERALD: But having regard to Mr. Jones's evidence, could one think that such a thing would make all the difference? Mr. Jones said the make was an impossible one. Continuing, he did not for a moment suggest that there was any intention on the part of Mr. Appleyard to deceive; but some mistake had been made in connection with the stocks. Then there was the deduction for increase in the price of coal—2s. 6d. per ton on 2279 tons, £285. On this point, the facts were really not in dispute. It was not in dispute that coal in 1912 was from 2s. to 2s. 6d. higher than in 1911, and that the figure of 17s. 3d. per ton given in the tables for 1912 represented the 1911 figure, and that in practically the whole of 1912 they were using the 1911 coal. Mr. Woodall agreed that when coal went up, residuals realized a higher price; but in the tables before them, whereas they had the 1911 price for coal, they had the 1912 price for residuals. Therefore the adjustment was made. The price of coal was still going up; and the 2s. 6d. he had referred to was a fair figure.

Sir CORBET WOODALL: Would you value the undertaking on a price which is admittedly abnormal?

Mr. FITZGERALD said if it could be shown that there was any prospect of coal coming down, this was a matter to be taken into account. But many things now combined to point to a continuance of the high price of coal; and he personally saw nothing pointing to a diminution in the cost. Then, of course, the price of residuals did not altogether follow the price of coal; supply and demand were the ruling factors. As to repairs, 5·05d. per 1000 cubic feet—the amount for the year

of account, which was less than the average—was very low. Here was a case where the year of account was the cheapest year for coal; repairs in that year were under the average; there was in that year the highest make of gas ever known, and the highest return from residuals ever known; there was in that year the lowest amount of leakage ever known; and, finally, in that year the net for coal was extremely low. There had been some extraordinary circumstances which had made the revenue increase largely in the year of account, and the expenditure go down; and the tribunal were asked to take this year, with all its peculiar features, as a normal year from which no deductions should be made Lastly, he submitted that the basis of purchase was a number of years which would enable the shareholders to get an equal income in an equally good security. What justification was there for asking more than 20 years – especially on an 11½ per cent. dividend, when they had never paid more than 10 per cent.? No gas security of any kind was bought on a 28½ years' basis to-day. In his experience, it was the highest price that had ever been asked; and he was not aware that it had ever been awarded. Again, it was very difficult to conceive how, in a small town like Sidmouth, an electricity undertaking could be profitable; and any loss there might be would fall on the gas undertaking, while at the same time the sale of gas would be reduced.

THE REPLY FOR THE COMPANY.

Mr. FREEMAN, replying on behalf of the Company, said that for many years the ordinary shareholders had had to go without their dividend; but the concern had been prudently managed, and had now reached a position of considerable prosperity. The works were good, with a large margin of capacity; and in the town and surrounding parts there were many houses actually waiting to be supplied with gas. The Company had accumulated money until they were in a position to pay a substantial back-dividend. Until they had paid this back-dividend in 1911, it was not natural that they should reduce the price of gas. The tribunal were valuing the concern under the Lands Clauses Act, without any special direction. They had to estimate the value of the undertaking as a whole in the hands of the vendors. The stipulation with regard to the paying off at par of the preference shareholders was made when the Company were not so prosperous, and it was desired to attract capital into the concern. It was not true to say that the value of the undertaking was not really the value of the undertaking, but was a fictitious value limited to paying off the preference shareholders at par, and the ordinary shareholders on the basis of their statutory dividend. It was all this, *plus* whatever available assets there might be. As to how the shareholders should divide the money might be a matter for them to settle among themselves; but the tribunal had to value the undertaking as a going concern, quite apart from these domestic arrangements. Then with regard to the position of the Company in relation to the debenture holders. If the Company had the power to compel the debenture holders to take their money at once at par, then, of course, any such claim as he was making on this head should go out. But if he was right in his contention that they could only make the debenture holders take their money on certain terms, then he was entitled to say what the terms were. Mr. Woodall had not put in the £19 for public lighting deficiency for the purpose of claiming it, but to show that there was this shortage in the year of account, and that if the consumption had been normal the income would have been so much larger. There was a balance of £195 shown after payment of a dividend, not of 10 per cent., but of 11½ per cent., with a lower price of gas. If an allegation was to be made, and evidence called upon it, that the agreed accounts were erroneous because of the way in which the public lighting was charged for, it was a pity that some representative of the Company was not present when the tests were made. The meters attached to the lamps could have been taken and tested; and this would have given absolutely reliable results. A point had been made as to a deficiency in the quantity of coal; but Mr. Appleyard had told them he had taken the greatest possible pains to ascertain what his stock of coal was, and there was not a scrap of evidence that he did not know the amount that he had in store at the beginning of the year. The only argument was that certain results were brought out by Mr. Appleyard which were not in conformity with the experience of Mr. Stevenson and Mr. Jones. It would be very dangerous if, because the result was different from what a gentleman who had managed other works would expect, they were to throw over the evidence of the Manager who was responsible for the thing. It was surmise against fact, and he asked them not to mulct the Company on a surmise. Then there was the difference of 2s. 6d. per ton in the price of coal. It was true that, as regarded three-quarters of the year, they were using 1911 coal, and that there was a rise in price in 1912—though he did not admit anything approaching 2s. 6d. But this did not exhaust the whole question. Would the figure which obtained in 1912 be such a figure as could be relied upon as representing the ordinary price of coal? He thought it was agreed that the 1912 and 1913 price of coal was abnormal; and he did not take so gloomy a view as his learned friend of what they would have to pay in the future. This was another illustration of fact against surmise. It had been said that there were some extraordinary things about the account year; but Mr. Appleyard had explained the reason for the better results. He was in that year using different coal from what he had ever had before. Mr. Woodall, when questioned, said he did not regard the results as abnormal. Even supposing that, knowing they were going to be bought up, they took special care to get the best out of the plant, and to reduce the leakage to the lowest point, was there anything wrong in that? Were they not entitled to get the best they possibly could out of the undertaking before selling it to another party? Special power was given to the Company under the Act to provide fittings and to charge for them. Whether it ought to be three or other number of years' purchase, he left to the tribunal. Were they going to reduce the amount which the Company said was their maintainable income because the figures sworn to by Mr. Appleyard and proved by Mr. Woodall and Mr. Brearley did not agree exactly with other figures of other gentlemen in other works? If his criticisms were correct, he had established without a doubt the fact that the Company could have afforded to reduce their price 6d. per 1000 cubic feet at once, and therefore earn 11½ per cent. He asked for this, and the dividend on the preference shares—making £1395. Coming to the number of years' purchase, there was no proof that the electrical installation would be a drawback to the undertaking But, in any case, the power to supply electricity was only permissive; and a scheme would not be entered upon if it was not thought that it would be profitable. It had been asked if anyone had ever heard of 28½ years' purchase. Well, Mr. Stevenson had claimed it himself in the Swinton and Mexborough case. There were many instances in which it had been claimed, though he could not, of course, state whether it had been given. To put forward such a figure as 20 years in a case of this sort, with a good Company, having a considerable surplus in plant, area, and revenue, was ridiculous. Now he (Mr. Freeman) came to the back-dividend. The Company determined, within their rights, to pay to the shareholders who had stood out of dividends in the lean times of the undertaking some of the money they should have had before. The alteration in the Act had been made long before the purchase clause was contemplated. To suggest that advantage had been taken of this alteration to do something they ought not to have done, was absurd. In the payment of this dividend, there was no moral blame attachable to anybody. It was said that some of these dividends were paid to persons who had only recently acquired newly-issued shares. This was true. The point had never been decided; but the dictum of one of the highest Judges in the land was that back-dividends were not limited to people on whose shares they were payable, but were payable on the whole capital of the company. Another thing was that the new shares were issued *pro ratâ* to the old shareholders, so that in reality the dividend was being paid to holders of shares who would clearly have been entitled, not only to that back-dividend, but to a good many more as well. Again, it had been suggested that something was wrong in respect of the transfer of £800 from the reserve fund; but though the words "reserve fund" had been used in reference to this £800, in fact and in law it never was a reserve fund at all. Section 31 of the Gas-Works Clauses Act dealing with reserve funds, said: "If the clear profits of the undertaking in any year amount to a larger sum than is sufficient, after making up the deficiency in the dividends of any previous year as aforesaid, to make a dividend at the prescribed rate, the excess beyond the sum necessary for such purpose shall from time to time be invested in government or other securities." The Company had a very large amount of back-dividends still unpaid, and therefore the circumstances had never arisen which were contemplated by this section. Though they called it a reserve fund, it was really carrying forward certain profits and holding them in suspense; so there was no possible reason why they should not have done as they did. Finally as to the 10 per cent.——

The UMPIRE: I think the tribunal are agreed that we are to have a free hand.

Mr. FITZGERALD then read a memorandum drawn up by Mr. Cash and accepted by both sides. This stated that the Council agreed to pay all liabilities of the Company, as per section 8 of the Act, including the overdraft at the bank, but less a sum of £50 as an allowance for the taxation of the costs, charges, and expenses of the Act of 1911; and the Company agreed to consider their claim for such costs, charges, and expenses to have been met in the payment of the overdraft.

This brought the prcceedings to a conclusion.

BELFAST GAS-WORKS EXTENSIONS.

Official Opening and Inspection.

The official opening and inspection of the new installation of vertical retorts, coke-handling plant, and spiral-guided holder at the Belfast Corporation Gas-Works took place on Monday, the 20th inst., and was made the occasion of a gathering of gas experts and engineers from various parts of the United Kingdom. Invitations were also extended by the Chairman and members of the Gas Committee to all the members and principal officers of the Corporation, and a number of leading citizens, to inspect the plant and afterwards partake of their hospitality, which was very lavish. An illustrated description of the plant (which was installed by West's Gas Improvement Company and Messrs. Robert Dempster and Sons) appeared in last week's issue of the "JOURNAL," pp. 175-181.

After the inspection, which was not accompanied by any formal ceremony, the company, numbering 150, adjourned to a large coal-shed in the works, which had been beautifully transformed and converted into a handsomely decorated dining apartment. The Lord Mayor (Councillor R. J. M'Mordie, M.P.) occupied the chair, and was supported by the High Sheriff of the city (Councillor James Johnston, J.P.) and the Chairman of the Gas Committee (Alderman James Craig). Luncheon over, the Lord Mayor gave the Loyal Toasts, which were honoured in customary fashion.

The LORD MAYOR, in proposing the Gas Committee, associated with the name of Alderman Craig, the very efficient head of this department of the Corporation, said it was difficult for a man who was not an engineer to speak with great intelligence on what they had just seen. In olden times it was considered by many a great misfortune if they got a machine that would dispense to any extent with manual labour; but he took it that in many places, and particularly in the City of Belfast, the introduction of machinery to perform all sorts of wonderful things freed an amount of intelligent labour that was qualified to conduct more important operations. It was a pity to convert an intelligent man into merely a living machine, to do work which an unintelligent machine could do, with a few tons of coal. He did not think there was any hardship in this; and the more of this kind of machinery that was introduced, the more they were doing for the operatives of the town, in enabling them to perform better work under better conditions. They had all been greatly struck with what they had seen; and even he could recognize that, in the new spiral-guided holder, they were decreasing friction and were increasing the steadiness of the movements, and were adding to the resisting power in certain directions. These matters were perhaps small; but in the aggregate they made a great deal for the effective working of the whole thing. He did not

know what further improvements were in store; but he did know that under the most efficient, intelligent, and enthusiastic attention given to the work by their Engineer (Mr. James D. Smith), and the persistent business attention given by the Chairman of the Committee, they expected all these efforts and the works now established would lead to very good results for Belfast later on. He did not suppose they had got to the final solution of things, or had determined everything. There was still room for improvement; and under the guidance of the Chairman and Engineer, they would still advance on what was already done. An extraordinary pronouncement was made at a meeting the other day by a professor who claimed to have arrived at a solution of the difficulty in regard to waste. He was a scientific man, and professed to have practically eliminated nearly all waste in the use of coal. This seemed to be one of the most far-reaching discoveries ever made for the benefit of the community in the matter of economy and efficiency. With the appliances now introduced in full working order, they would not be left behind, and they would be able to adapt anything and everything in the way of new suggestions that might be for the benefit of the general public.

Information as to the Undertaking.

Alderman Craig (who was received with applause) responded on behalf of the Gas Committee, and extended a cordial welcome to all present. They were, he said, met to celebrate the inauguration of the first section of their scheme of extensions at the gas-works; and when they had their plans completed, he thought they would be able to claim the possession of one of the best gas concerns in the United Kingdom. It would not be out of place if he gave a short account of the history of the works. Founded in 1823, the success of the undertaking was for a long time in doubt; but after being thirty years in operation, matters began to improve. When the gas undertaking was acquired by the Corporation, in 1874, the make of gas was 415 million cubic feet, whereas for the year ending March 31, 1912, it had reached 2338 millions. On the other hand, the price of gas in 1874 was 4s. 6d. per 1000 cubic feet, less discount; the present price being 1s. 9½d. net—a price which would compare favourably with that charged in any other city in the United Kingdom. It was soon seen, however, that more space would be necessary to meet the demand for gas; and accordingly, in 1880, the then Engineer (Mr. James Stelfox) called the attention of the Council to the fact. But nothing was done; and the congested state of the works increased from year to year, until 1891, when it was proposed to take a portion of the Ormeau Park for gas-works purposes. Owing, however, to objections raised on behalf of the ratepayers, it was decided to abandon this scheme, and the matter was allowed to lapse. The situation was saved by the introduction of carburetted water gas in 1893. Owing to the small amount of ground-space required for the plant, and the speed with which gas could be manufactured, they were able to struggle along, with the aid of other alterations and additions from time to time. About 1908, the question of extensions was again raised; but nothing was settled until after the appointment of the present Engineer in 1910. Immediately after assuming command, Mr. Smith went into the whole question, and submitted an exhaustive report, in which he recommended, mainly, that additional ground should be acquired on the other side of the Blackstaff, on which to eventually erect a large holder and purifiers, the substitution of vertical retorts for the present carbonizing plant as worn out, and the removal of several small holders in order to provide additional ground-space. These recommendations were adopted by the Council in the latter end of the year. No time was lost in preparing plans and specifications; and West's Gas Improvement Company secured the contract for providing a vertical retort installation capable of producing 2½ million cubic feet of gas per day, while the contracts for a new gasholder of 3 million cubic feet capacity, to be erected on the site of the existing No. 5 holder, and telpher plant for handling coke, were given to Messrs. Robert Dempster and Sons. These contracts were entered upon in the early part of 1912, and were due to be completed in September last. The time allowed for work of such magnitude was short; but it was necessary that the plant should be completed before the present winter's work came upon them, and he was pleased to say that they were able to get the various appliances into operation in good time. The Committee were lucky in their choice of contractors, as he did not think it would be possible to find two firms with a higher ideal of duty to their clients. The past year would long be remembered for the coal strike, and consequent dislocation of trade; and the contractors had it to contend with, in addition to the ordinary trials and tribulations to which he understood all contractors were exposed. Coal not being obtainable, it was impossible to get the necessary machinery constructed till long after the time expected, and even when ready for shipment the delays were enormous, owing to the congestion caused by the strike. It had been said, however, that difficulties were only made to be overcome; and evidently the contractors took this view, for they spared no pains to keep their contract time, and were deserving of every credit for their efforts. He need not say anything as to the class of work turned out, as they would be able to judge for themselves; but he thought it would be safe to state that the reputation of the firms for honest work had been considerably enhanced. He should point out that the large expenditure at present being incurred was the direct result of past years of inaction. Had room been available for extensions during the last twenty years, a portion of the present outlay would have been spread over that period, and their Engineer would not be exposed to the great anxiety and worry which he had had, and would have, to contend with for many years to come. The Committee felt, however, that the concern was in capable hands, and had every confidence that Mr. Smith would devote his undoubted ability to converting the works into the model gas undertaking of the country.

Belfast's Industrial Position.

Mr. Walter King (London) gave the toast of the "City and Trade of Belfast." In doing so, he said that when their Gas Engineer (Mr. Smith) intimated to him that the privilege would be afforded him of proposing the toast, he felt it a great honour. It was also a great relief to him to know that such a toast needed few words from one who did not belong to the city. That trade in Belfast was in a prosperous condition was manifest from the fact that the extensive additions to the gas-works which they had inspected that morning were so urgently required. His experience and that of others in the gas profession told him that trade not only "followed the flag," but that it was a sure index of commercial prosperity and progress to see how the consumption of gas was extending in any particular place. If the statistics of the gas supplied in Belfast during the last few years were examined, it would be seen that the rapid increase in the demand synchronized with the well-being and prosperity of the various local industries—and they were many. Belfast for its flax and linen trade, its enormous shipbuilding facilities, its whisky and tobacco factories, was world-famed; and one never thought of these industries and their allied branches without unconsciously connecting them with this part of the North of Ireland. He concluded by congratulating the Gas Committee on the proofs of their enterprise which the visitors had seen that day. The new plant just started would be sufficient to meet the demands for the manufacture of gas for, at all events, a few years to come; but old as he was, he was still hopeful that he would be asked to come back to see further extensions in a few years' time. Gas was really quite in its infancy; and he felt sure that the Committee would require further extensions before very long. It was with the greatest pleasure that he gave the toast of the "City and Trade of Belfast," coupled with the name of the High Sheriff of the city (Councillor James Johnston).

The toast was drunk with enthusiasm.

The High Sheriff, in replying, said those responsible for the acquisition of the gas undertaking had shown great foresight in securing these magnificent works for Belfast. Going back only thirteen or fourteen years, he found that during this period the Gas Committee had contributed towards the interest and sinking fund on the City Hall a sum of £100,000, besides giving £150,000 in relief of the rates. These figures would show the wisdom of their predecessors in purchasing the concern for the ratepayers. There were some people who were opposed to municipal trading, and he had to confess that he was not very keen on it himself. But there were some departments of trading that should be in the hands of the Corporation—such, for instance, as the gas-works, the electricity works, tramways, and markets. The present value of their gas-works was upwards of £1,000,000; and if they took credit for the redemption of stock in the books of the Corporation up to last year, the amount against the undertaking was only £378,000, leaving to posterity a very ample asset indeed. The valuation of the city in 1874, when the concern was taken over by the Corporation, was about £500,000, whereas it was now £1,560,000; and in the same period the population had advanced from 185,000 to about 400,000. The rates twenty years ago were 4s 5d. and 5s. in the pound, while last year they stood at 4s. 2½d. and 4s. 8d.; and he believed the difference was largely accounted for by the success of the municipal trading undertakings. In speaking of the prosperity of Belfast, it was only fitting that they should refer to the work of other public Boards. They all recognized how well the members of the Harbour Board discharged their duties; while as for the Water Commissioners, it would be remembered that during the summer of 1911 considerable alarm was felt regarding public supplies of water owing to the prolonged drought. The pinch was not felt so keenly in Belfast as in the majority of the large cities throughout the country; but last year the Commissioners went to Parliament for a Bill, and the result was that all their tanks were now filled to overflowing, so that, after all, the new Silent Valley reservoir might not be much needed. He thought it could be honestly stated that Belfast was never more prosperous than at the present time.

The Contractors.

Councillor Edwin Squire, the Vice-Chairman of the Gas Committee, proposed the toast of "The Contractors," coupled with the names of Mr. F. J. West and Mr. J. W. Broadhead. The toast, he said, was an expression of appreciation, and a proposal to recognize virtue and merit. He thought it only fair to ask the question, which many in the room could answer better than he could, why Belfast was going to honour their Contractors. They had done their work remarkably well, and deserved to be honoured. In 1906, when the question became extremely acute, as to what would be done to meet the abnormal increase in consumption yearly taking place, they knew very well they were going to spend an enormous amount of money. They travelled a good deal—at any rate, he went to a number of places, and saw a great many installations of various kinds. It was absolutely necessary, as they would agree, that they should, for a city like Belfast, go in for the very best plant. Whether or not it was their fault, they could not make up their minds for three or four years; and he thought they were wise not to do so, because at first they rather favoured the intermittent system, whereas the retorts they eventually selected were continuous. They saw several good firms, and some remarkably good machinery in the gas-making world; and after examining them all very carefully, they came to the conclusion, for three reasons, that the retorts of West's Gas Improvement Company were the best. Their solidity greatly attracted the Committee. When once the retorts were put down, they were practically down for ever—or, at least, as long as anyone present would live, and a good deal longer. Their simplicity and their cleanliness were also in their favour; and he was sure that any gentleman present who had looked at the retorts could not but be struck by their compactness. Freemasonry among gas people was simply marvellous; for they let one know everything they were doing, and thanked one for coming to see it. These retorts were at work in St. Helens, Bradford, Tokio, Newcastle (N.S.W.), and other places, and were, he believed, very successful there. He was sorry his friend Mr. Blair, of Helensburgh, was not there, because he had convinced him personally about the putting down of the right sort of retorts. They had adopted the West system; and the firms to whom they had entrusted the necessary work had done it well. Both firms of Contractors were renowned for honest workmanship and for straight dealing.

Mr. F. J. West thanked the company for the manner in which the toast had been received, and said that to a contractor who had endeavoured to do his duty the remarks that had fallen from the lips of the several speakers were very gratifying. As representing a firm who had for many years put forward labour-saving appliances, he might remark that one of the great difficulties they had had to encounter was the pessimistic attitude that had been adopted by members of many gas committees. Speaking for himself, from several years' experience as a member of

the Manchester City Council, he knew that many members of the committees he served on had always said, "Let somebody else try a certain plant first." He was very pleased this had not been the attitude that had been pursued by the Gas Committee, or by any Committee, in Belfast. He ventured to submit that the position the Belfast Corporation occupied was due to the optimistic and progressive attitude that had been adopted by the members of the Corporation. During the carrying out of the work, the Contractors had been very ably assisted and supported, and had had the co-operation of Mr. Smith and his chief officials in every manner possible.

Mr. J. W. BROADHEAD next responded, and said he was very thankful for the kind remarks that had fallen from Councillor Squire and from the Chairman of the Gas Committee, with reference to the Contractors. He was very proud to be present as one of the Contractors to the Belfast Corporation. It would, perhaps, be of interest if he told them something of the spiral-guided holders, one of which they had seen. The principle of the spiral-guided holder was invented about thirty years ago; but the then engineers were not so ready to perceive the advantages of the system as the Lord Mayor, who had grasped them, as was shown by his speech. Progress was slow for many years. But in time engineers began to realize its advantages; and while in the early days they adopted it for cheapness, at the present time 95 per cent. of the holders were erected on this principle, and the system had been adopted because of its strength. The firm he represented had specialized for many years in the construction and erection of spiral-guided holders; and he was proud to be able to say that they had erected more of them than all the other firms put together. He wished to compliment Mr. Smith on having designed a holder stronger than any they had yet erected, and one calculated to give every satisfaction, not only to the Gas Committee, but to the citizens of Belfast. Referring to the telpher plant, he said it was first put into gas-works about eight years ago. Now about fifty gas-works had the plant in operation or under construction. Gas engineers were not averse to extending a helping hand towards electricity. The telpher plant was driven by electricity, which had its advantages, particularly when portability had to be considered. One of the great advantages of the telpher plant was that only a very small part of the contract sum was invested in moving machinery; and, as they had seen, this moving machinery was very compact, and wear and tear were negligible quantities. He should like to thank Mr. Smith for the courtesy he at all times extended to the Contractors, and particularly for the kind consideration he showed in the period in which they laboured under great disability, owing to the coal strike, from the effects of which he was sorry to say they had not yet recovered. He should also like to thank the staff for their help in the carrying out of this important contract, and to congratulate the Corporation upon the completion of the first section of the remodelling of the original gas-works. He ventured to submit that no one would regret that, on the Engineer's advice, they decided to stick to the site and make the most of it.

A PRESENTATION.

It was customary, concluded Mr. Broadhead, on an occasion of this sort, to ask the acceptance by the Chairman of the Committee of a little memento of the event; and he had great pleasure in asking Alderman Craig to accept, on behalf of the Contractors, as a souvenir, a silver rose bowl, bearing the inscription:

> Presented to Alderman James Craig, the Chairman of the Belfast Corporation Gas Committee, at the inauguration of the vertical retorts, spiral gasholder, and coke-handling plant.

The LORD MAYOR, in handing the gift to Alderman Craig, said that everyone was delighted to know that the efforts of the Committee had been so much appreciated.

Alderman CRAIG, in response, said this item on the programme had taken him by complete surprise. The beautiful present would be kept by him and cherished as one of his most valuable possessions, and he thanked the Contractors for the kindness and consideration they had shown to him.

Councillor FRANK WORKMAN, in the absence of Councillor James A. Doran (ex-Chairman of the Gas Committee), proposed the health of "The Visitors," in a humorous speech, in the course of which he said they were delighted to have with them that day so many gentlemen distinguished in the gas profession. He understood from Mr. Smith that he had had a great deal of valuable information from experts on the other side of the Channel, to assist him in carrying out the great undertaking which they had seen that day. He hoped they would be satisfied with what they had seen, and that possibly they would learn a little from it, just as those in Belfast had learned from them on similar occasions. He coupled with the toast the name of Mr. Charles Wood, of Bradford.

Mr. CHARLES WOOD, after thanking Mr. Workman for his kind words, said that, like Mr. Workman, he was only a substitute, for he was sorry that Mr. Alexander Wilson, of Glasgow, was not present to respond to the toast. He was very grateful for the kind manner in which the visitors had been received that day, and assured them, on behalf of his friends, that they appreciated it very much. Looking round the room, which he understood was a coal-shed, he was struck by the possibilities of what could be done in the gas-works of the United Kingdom by the introduction of vertical retorts. If other gas engineers and gas committees saw the room, they would be only too glad to go in for vertical retorts. He came from Bradford, which had, he thought, the largest instalment of the kind; and as one who had travelled perhaps as far as anyone, he could assure them that they would never regret having gone in for vertical retorts. It was some years since he was in Belfast; but he remembered looking at the site of the proposed extension somewhere at the sea, or almost there, and he could congratulate everybody responsible for the finances of Belfast on having corrected what might have been a very serious mistake—viz., to build gas-works out at sea. It did not appeal to him at all. They had fine gas-works and plant, and had a right to be proud of them. He hoped he would soon be back to see some further extension of the vertical retorts.

Councillor COATES gave the health of the Chairman, which was drunk with enthusiasm, and acknowledged by the LORD MAYOR.

DOUNE TOWN COUNCIL AND THE GAS-WORKS.

The Transfer Completed—History of the Undertaking.

It was mentioned in the "Notes from Scotland" a fortnight ago that the gas-works at Doune, in Perthshire, passed on the 7th inst into the hands of the Town Council. They were formally handed over at a meeting which took place subsequently at the works, on the invitation of the Directors of the Gas Company. The Chairman (Mr. W. D. Thomson) presided, and expressed the great pleasure it gave him, and he was sure his co-Directors also, to meet the Town Council on the occasion, as they were persuaded that the burgh had acquired the gas-works on terms advantageous to the public. It now rested with them to conduct them to the best advantage; and he was of opinion that the undertaking ought to be to the burgh what it had been to the late shareholders—a good investment. In formally handing over the works, it might be interesting to recall what took place fifty-five years ago, when the proposal was first made to introduce gas into the village. A meeting of inhabitants was held on Dec. 22, 1857, when it was pointed out that the village would shortly have a railway running past it, connecting with the coalfields. A Committee was appointed to gather information and report. At a meeting held on Jan. 12, 1858, an offer was submitted from the Deanston Company to supply gas on certain conditions; but the meeting thought it better to have works of their own. The capital was fixed at £1200, and £448 was at once subscribed. The present site was fixed upon, after many negotiations, on April 21, 1858, at 30s. per annum on a lease for 99 years. There seemed to have been a good deal of trouble with contractors and others during the erection of the works; but a minute of Oct. 7, 1858, read: "Gas successfully manufactured on Oct. 6, 1858, and the part of the village already supplied with pipes, brilliantly lighted with gas on Thursday night, Oct. 7, 1858." Up to June 6, 1859, the works had cost £1452. The price of gas to begin with was 11s. 8d. per 1000 cubic feet; while at June, 1862, it was 9s. 2d., with meter-hire of 2s., 3s., and 4s. per annum. The new Company registered under the Limited Liability Act took over the old concern; and, considering the price of gas charged, and the amount of capital spent to bring the pipes and plant up to date, they did not do badly for the public. In fact, during all the time that he had had any knowledge of the working of the Company, the Directors had always been anxious to consider the public; and the shareholders and a dividend were not the only considerations. It was well that this was so; and now it was good for the people of Doune that the Directors did not selfishly build up a very valuable concern, which would have put it out of the power of the town to purchase. Lighting was essential to the well-being of the community; and he hoped the Town Council would be enabled to extend the scope of the gas-works and give a cheaper and even better light, with more of it on the streets, and be supported by the inhabitants availing themselves of the opportunity of obtaining both light and heat. He concluded by expressing the appreciation of the Directors and himself of the courteous and reasonable spirit that had existed during the negotiations which had now ended so amicably for all concerned.

MANCHESTER COMMITTEES AND RATE AID.

A Scheme Adopted for Twelve Months.

The Manchester City Council, at an adjourned meeting last Wednesday, arrived at a decision on the report of the Trading Profits Special Committee, which had been discussed on previous occasions. The Committee were appointed in 1911 to consider and report as to the basis on which each Trading Committee of the Corporation should make contributions in aid of the city rate. The Committee recommended that for a period of three years the Gas Committee should contribute in aid of the city rate 1¾ per cent. on the capital expended; the Electricity Committee, 1 per cent.; the Tramways Committee, 5 per cent.; and the Markets Committee, 2 per cent. Practically, a resolution had been moved to adopt the report; and an amendment was before the Council to have it referred back for further consideration. Ultimately, this amendment was defeated; but another was carried to the effect that the recommendations should only remain in force for twelve months instead of three years, and in this form the report was adopted.

Alderman PLUMMER argued that it was altogether wrong to hold that consumers of gas or electricity were entitled to all the profits of the gas and electricity undertakings. This idea, if carried to its logical conclusion, would mean that the Markets Committee should make no profit from the letting of stalls. He insisted that, as the ratepayers were in the last resort responsible for the financial burden of all these trading undertakings, they were justly entitled to a reasonable return. Such a return would be 7½ per cent. on the capital employed. If this principle were accepted, it would mean that the city would get £8951 more from the Gas Department than it did now; and in the case of the Electricity Department, the rate contribution would be £28,356, instead of £24,500, the sum contributed for the current year.

Mr. JACKSON held that it was difficult to discuss anything in the nature of a rational basis on which each Trading Committee should make contributions in aid of the rates on the recommendations which had been made by the Committee. It was entirely wrong to accept any contributions to rate-relief from trading departments of the Corporation, whose primary object was to supply a service to the community in matters of public convenience and utility. The Markets Committee ought to contribute something, because the profit was not of the nature of invested capital, but of rent. The objection to the profits from the trading departments was that these entered into the price of the commodity. On the whole, it was the workers who would benefit by cheaper services as against the system of relief in rates.

Mr. CHANTLER asked whether, supposing they abolished trading for profit, Committees would be capable of working with the same spirit and enterprise as at present. Would the departments be as well

conducted? He thought the Council would be well advised to accept the report, and to support the Committee's recommendations.

Mr. HELM was opposed to raising money by the higher charges on what might be called necessaries of life; and if these profits were not made, he thought the increase of rates would not be more than 2d. or 2½d. Tramcars and gas, if not actual necessaries of life, were nearly so. He had never been able to see why those who used Manchester tramways and gas should be compelled to pay more for them so that the rates might be relieved. Cheap trams and cheap gas struck at the very root of the welfare of the people. He asked the Council to send back the report for further consideration by the Special Committee.

Mr. GODBERT spoke in favour of referring the report back, and held that it would be unwise to bind the action of the Council for three years. A serious cost was now incurred by owners of public buildings in cleaning them because of the sootiness of the atmosphere. The latter condition would be improved by the greater use of gas, which would be promoted by the lowering of the price.

Mr. ABBOTT asked what was the legal position of the Council. Was it competent for the present Council to bind their successors for three years?

The TOWN CLERK: The Council are quite competent to pass the resolution adopting this report. They would be equally competent this day twelve months to rescind the resolution.

Alderman COPELAND, the Chairman of the Special Committee, referred to the circumstances in which the Committee came to be appointed in 1911. He said that they were to consider and report to the Council as to the basis on which each of the Trading Committees of the Corporation should make contributions in aid of the city rate. This had been done, and the matter had been fully debated in the Council. He thought they could now come to a decision. The Council ought to consider whether they should base the percentage of payment on the capital amount of expenditure or on the outstanding debt. If they took the latter as the basis, he thought they would be acting wrongly. The conclusions come to by the Committee had been carefully thought out, were reasonable, and ought to be accepted. It would be much better to adopt the system recommended in the report, and relieve him, as head of the Finance Committee, from the unenviable task at the beginning of each financial year of going to the Trading Committees and pressing them to contribute the largest possible sum. He agreed with some speakers who had suggested that the working classes were more greatly benefited by these contributions to the rates than they would be by a lowering of the charges for gas. For instance, the number of assessments in Manchester of £35 per annum and over was 22,691, whereas the number of assessments of £25 and under was 162,237. This showed that they had to deal with a large number of comparatively small ratepayers; and if they put 10½d. in the pound on the present rates—as they would have to do if they did away with the profit contributions—they would be placing a great burden on the poorer ratepayers.

LIMERICK CORPORATION GAS UNDERTAKING.

Alleged Serious Irregularities.

The Special Committee of the Limerick Corporation, who have for several months been investigating the working of the gas undertaking, have presented to the Council a report detailing what are considered to be serious irregularities which have involved heavy loss to the ratepayers.

The report sets forth that the inference to be drawn from figures shown in the Gas Committee's books and documents was that the falling-off in profits for 1905 and some subsequent years was due to the use of inferior coal and purchase at a higher rate than in 1904; and that the Gas Committee took no steps to remedy the matter. In 1905 a change in coal was justified by the certificate of the Engineer, which stated that the difference would be 585 cubic feet of gas per ton in favour of the new coal tendered for, against another coal for which a tender had been received, The actual results were not according to the certificate; but the fact was not investigated. Owing to complaints of the inferior quality of the gas, the Committee decided to obtain some trial cargoes. The Auditor in 1905 pointed out that the profits had fallen to £308; and the reduction of income, amounting to £2687, was accounted for by the introduction of electric lighting—there being a consequent reduction in the yield of residuals. The report declares that the profit was less by £3385, due to the consumption of coal being less by 857 tons; and that there was £400 loss of receipts owing to the reduced price of gas sold, greater expenditure, and purchase of dearer coals. A better quality of gas, however, was produced. When the contractors declined in 1907 to continue the coal contract, a special cargo was obtained at a higher price, and the non-execution of a new clause in the specification led to a loss of £900. The supplies in 1910 gave the best results of the period covered by the Special Committee's inquiry. The shutting of the door to competition and the creation of a virtual monopoly are declared to have been injurious to the gas concern. One firm's tender was accepted for from 10,000 to 12,000 tons of coal at 20s. 4½d., while a tender at 18s. 11d. was not accepted; and last year again the same firm obtained a like contract, though there was a tender at 16s. 9d. for 5000 tons, and one at 16s. 3d. for a like quantity. Results in 1911-12 gave a reduced yield of gas compared with 1910-11, though the same quantity of coal was carbonized.

The irregularities specified by the Special Committee are: Purchases of coal by the Engineer without the authority of the Gas Committee; payments to contractors for larger quantities of coal than those stated in the bill of lading; passing of contracts for works and materials without proper specifications of the work to be carried out and the material to be supplied outside the contract. It is observed that coals have since been checked by passing occasional test loads over the gas-works weighing-machines; the results being 63 per cent. more satisfactory than before.

At a special meeting of the Town Council, at which the report was read and ordered to be printed, Mr. M. Griffin declared that there had been a loss of thousands of pounds by the way in which the gas undertaking had been conducted; and the people should rise against it. Was there not a recommendation by the Special Committee for a sworn inquiry into the whole business? Mr. O'Brien said that they could consider this matter when the report had been printed.

FATAL ACCIDENT AT THE BECKTON GAS-WORKS.

Last Wednesday, Mr. H. R. OSWALD, Coroner for the South-Eastern District, held an inquiry, at the Co-operative Institute, Woolwich, relative to the death of Alfred Thomas Watts (49), which occurred as the result of an accident he met with at the Beckton Gas-Works on the previous Saturday.

Mr. C. BEASLEY ROBINSON (Messrs. Monier-Williams, Robinson, and Milroy) appeared for the Gaslight and Coke Company; Mr. EDWARDS (Messrs. Kilsby and Edwards) represented the widow; and Mr. H. M. SHUTER, one of the Inspectors of Factories, attended from the Home Office.

George Robert Barnes, a coal porter, deposed that the deceased was engaged in lifting coal from the ground into the railway waggons. When the coal was moved into heaps, a grab, worked by a steam-crane, came down, seized it, and tilted it into the waggons. The place was well lighted by a large oil-lamp. Trott, the hold clearer, had given instructions to keep clear of the grab. He (witness) was making up a heap of coal when he heard a crash, and found the grab had fallen; and he saw the deceased lying unconscious in the 4-feet way close to the waggons. A doctor was sent for immediately, but Watts was dead when he arrived.

By Mr. EDWARDS: If was easy to keep clear of the grab by stepping back out of the way. At the time of the accident, deceased was acting just the same as he always did.

By the INSPECTOR: He had never known the grab to come down accidentally; but on this occasion he thought it did.

Alfred Trott, hold clearer, said the deceased was standing by the side of him when he gave the order to the crane driver. Witness then walked towards the waggon to tell the men where to have the next grab. The deceased shot by, and the grab came down upon him.

By the CORONER: The same work had been going on for years, and he had never heard of anyone being hurt. In his opinion, it was a pure accident.

By Mr. ROBINSON: The deceased was standing behind him, and he came forward, which he should not have done. He should have waited till the grab was clear.

John William Rungary, crane driver, stated that he was driving the crane when the accident happened. There was plenty of light. Having received the order from Trott, he lowered the grab and seized some coal. Having taken this up, the grab was hoisted until it hung over the waggon, and then it tipped in the coal. What happened was that in the act of the winding the grab it slewed on to the dog clutch, which was next the main guide to the hoisting gear, worked it out of its position, and thereby allowed the grab to descend rapidly. He immediately applied the brake with his foot. In the act of the grab falling it struck the waggon, rebounded, and fell upon the deceased. There was no time to prevent it falling. It was up in the air about 8 feet. He had been a crane driver for twenty-five years, eleven with the Company, and had never before known a grab come down in the way described. Witness explained the operation of the mechanism, and said he examined the clutch immediately after the accident, found it in good working order, and could discover no defect in it.

By Mr. ROBINSON: He heard Trott, just before the accident, tell the trimmers to keep clear of the grab.

By Mr. EDWARDS: The cranes were examined every month, and the joints oiled every alternate day.

By the INSPECTOR: He did not think there was any practice to overhaul them periodically; but they were thoroughly overhauled on certain occasions. There were no pinholes; and it was not usual to have them in the class of crane used. If they had been there, it might have prevented the clutch slipping out of position.

The FOREMAN: Do you think it was a defect in the clutch that caused it to get unshipped?

Witness said it was quite possible some defect arose at the moment, as defects in machinery cropped up instantly.

Charles Tayler, crane driver, said he examined the machine at eight o'clock on the morning after the accident, and there was nothing the matter with the dog clutch, the brake, or any part of it. There were no bolts loose.

By Mr. EDWARDS: It could be seen that the machine was in perfect working order without adopting any practical test.

Mr. ROBINSON said he had a witness present who could speak to the periodical examination of the machine,

The JURY, however, intimated they did not think it would be of the slightest utility, as they had heard the evidence.

Dr. *John Guest* said he was called to see the deceased on the day of the accident; but he had been dead a short time when witness reached the works. Having described the nature of the injuries, he said the cause of death, which would have been practically instantaneous, was shock.

The CORONER having summed up the evidence,

The JURY briefly conferred, and returned the following verdict: "The Jury are quite of the opinion that it was an accidental death; but they believe, as practical men (and they nearly all are practical men connected with machinery) that the accident would never have occurred if there had not been a defect in the machinery when the clutch slipped while the weight was on the crane."

Mr. ROBINSON remarked that there was no evidence to this effect.

The CORONER: No. [To the Jury:] Do you add that as a rider, or as an expression of opinion? because there is no evidence of it.

The FOREMAN: No; but the opinion of the Jury is that the accident would never have happened if the dog clutch had not slipped.

GAS v. ELECTRICITY FOR COOKING.

Suggested Competitive Trial at Newport (Mon.).

Lectures are now being delivered in Newport (Mon.) by Mr. F. S. Grogan, under the auspices of the Electricity Department of the Corporation, on the subject of cooking by electricity; and in the report of one of them which appeared in the "South Wales Argus" on the 22nd inst. the following statement was made: "It is a fact that more than four-fifths of the theoretical heat available from gas is wasted." This assertion was naturally challenged by Mr. Thomas Canning, the Engineer of the Newport Gas Company, who asked the Editor to give his authority for the so-called "fact," at the same time explaining that by "authority" he meant the name or names of the expert or experts who discovered the "fact," and the report of the results of the tests, and the time when and place where they were made. This request brought the following reply from Mr. Grogan: "I have personally proved this [the 'fact'], and published the results in the 'Electrician' and other technical papers in February, 1911. Apart from this, the public have repeatedly verified this statement as the result of actual practice in using electric cookers. For instance, at one of the lectures at the Town Hall, a gentleman publicly stated he had satisfied himself, since using the electricity cooker, that it cost less to operate than his gas-cooker. He was able to give the actual figures from the use of both electric and gas cookers, showing that for similar operations electric cooking cost 2¾d., against gas cooking 3½d. Now, Sir, 2¾d. worth of electricity produces theoretically 9500 B.Th.U. of heat; 3½d. worth of gas produces theoretically 48,500 B.Th.U. of heat (assuming the calorific value of gas at Newport to be 500 B.Th.U. per cubic foot). Therefore, in actual practice, it is obvious that at least four-fifths of the theoretical heat available from Newport gas is wasted when used in cooking. If Mr. Thomas Canning will honour me with his presence at any of my remaining lectures, I shall welcome the opportunity of dealing with the question from either the technical or the practical standpoint, whichever he prefers."

In his letter, Mr. Canning replied as follows: "Mr. Grogan has replied to my letter, but has not answered my queries. He has not given the particulars of any tests, or any data whatever, for justifying his statement 'that more than four-fifths of the heat available from gas is wasted.' He has simply referred me (1) to himself, (2) to the public, (3) to a gentleman in the audience at one of his lectures. In regard to Mr. Grogan's own authority, I will endeavour to procure copies of the 'Electrician,' for February, 1911; but until I have ascertained the conditions under which he made his test, and subsequently verified them, I must reserve my opinion.

"The appeal to the public can be made only in one way, and this way I have indicated in the closing sentences of this letter. The statement of the gentleman in the audience that by paying 2¾d. for electricity he had as much cooking done as when he paid 3½d. for gas must be taken for what it is worth. But whether it applies generally can only be answered by comparison with very different results of accurate tests already made, showing the cheapness of gas, and by a repetition of similar tests here.

"That there should be adequate tests of the two systems of cooking becomes all the more imperative because Mr. Grogan builds his whole case upon the gentleman in the audience. For 2¾d., says Mr. Grogan, you get 9500 B.Th.U. of heat from electricity as against 48,500 B.Th.U. from gas costing 3½d. But, owing to waste, these 48,500 units of heat do the work of only 9500 units. Mr. Grogan does not attack the thermal value of gas, but the efficiency of the gas-oven. If the oven were improved, therefore, and the waste stopped, electricity would fare badly; for then the equivalent of 2¾d. for electricity would be obtained in gas for 0·7d.—that is, less than ¾d.—as against 2¾d.

"In passing I should like to make one comment on what has struck me in regard to the inconsistency of Mr. Grogan and electricians generally in dealing with this question of cooking by gas. At one time it is stated that the superabundant heating power of gas causes deplorable shrinkage in the cooked joint, and again it is stated that the heat in a gas-oven is less than in an electric cooker. May I point out that both these statements cannot be correct? May I, without offence, say that I find it impossible to accept either statement as being correct?

"Mr. Grogan has kindly invited me to hear him lecture, when he says he will deal with this question from either the technical or the practical standpoint. Now, I shall be glad to deal with it from both standpoints; but Mr. Grogan's invitation does not include quite enough. In order to test the 2¾d. against the 3½d., something more is wanted. I respectfully ask Mr. Grogan to propose to the Electricity Committee that they shall arrange with the Gas Company a trial of gas-cookers and electricity cookers under conditions, to be settled between them, that shall be fair to both parties. Further, I propose that the tests so made shall be thorough, carried out in public, and the results published. I am authorized by the Chairman and Directors of the Gas Company to say that, if a suitable arrangement for a really fair working test can be arrived at, it will have their sanction and support."

TWENTY YEARS' GAS SUPPLY IN BRUSSELS.

Some Noteworthy Statistics.

The "Journal des Usines à Gaz" for the 20th inst. contains some interesting statistics of the gas supply in Brussels in the period from 1891 to 1911. The former year was selected as the starting-point because the average price of gas—13·09c. per cubic metre, or about 3s. per 1000 cubic feet—has not since varied to any great extent. From 1886 to 1891, it was lowered from 16·14c. to 13·09c. per cubic metre—the former figure being equivalent to about 3s. 8d. per 1000 cubic feet—or a reduction of more than 18 per cent.; while from 1891 to 1911, it only dropped from 13·09c. to 12·16c. per cubic metre (about 2s. 9d. per 1000 cubic feet), or 6·3 per cent. It will be noticed from the tables that, in the period of twenty years taken, the quantity of gas used for the public lighting fell off in the last ten years; that the gas used for motive power, after increasing considerably for fifteen years, is diminishing appreciably; that during the period just named private lighting augmented slightly, and then remained practically stationary; and that the consumption of gas for heating purposes increased to an unexpected extent from 1896. It should be mentioned that the figures refer to the gas supplied by the Municipality only.

The following tables contain the statistics for the four quinquennial periods in the twenty years taken:—

—	1891.	1896.	1901.	1906.	1911.
Average price of gas per cubic metre	13·09 c.	12·50 c.	12·22 c.	12·16 c.	12·16 c.
Number of inhabitants	176,893	180,663	184,440	193,695	176,947
Gas sold per inhabitant	120 c.m.	146 c.m.	192 c.m.	203 c.m.	225 c.m.
Number of meters	14,852	20,202	32,023	40,259	47,146
Gas sold per meter	1433 c.m.	1309 c.m.	1103 c.m.	975 c.m.	846 c.m.
Total gas sold, cubic metres	21,294,344	26,315,522	35,353,563	39,287,099	39,897,963

The following table shows the various purposes for which the gas was used; the figures being cubic metres (1 cubic metre = 35·3 cubic feet):—

—	1891.	1896.	1901.	1906.	1911.
Lighting	16,504,321	22,207,892	26,92 ,835	28,870,985	28,762,759
Heating	*2,876,717	1,064,239	3,357,835	4,960,373	7,127,969
Motive power	811,872	1,555,693	3,470,199	3,573,593	2,124,036
Public establishments	888,318	927 702	1,315,800	1,620,053	1,643,525
Workmen's dwellings	..	†	21,465	31,174	24,522
Illuminations, &c.	154,045	140,186	80,337	51,346	56,147
Miscellaneous	59,071	420,810	183,622	179,575	159,506
Total gas sold	21,294,344	26,315,522	35,353,563	39,287,099	39,897,963
Public lighting	4,124,819	4,606,676	5,145,197	2.905,997	3,863,749
Works and offices	831,227	1,031,122	1,639,322	1,817,062	1,449,416
Unaccounted for	1,596,820	1,157,770	1,177,298	839,952	1,422,782
Total output	27,847,210	33,111,090	43,315,380	44,850,110	46,633,510

* These figures comprise 2,678,620 cubic metres of gas used in the daytime, and 198,097 cubic metres employed for industrial purposes.

† The 420,810 cubic metres of gas put down as "Miscellaneous" include the supply to the workmen's dwellings.

The variations in the sale of gas for its principal uses in the four quinquennial periods are shown in the following table; the figure 1000 being taken for the typical year:—

—	1891.	18 6.	190 .	1905.	1911.
Lighting	1000	1346	1632	1749	1743
Heating	*	1000	3155	4661	6700
Motive power	1000	1913	4278	4405	2619
Public lighting	1000	1116	1247	704	936

* The figure for 1891 is not sufficiently reliable to be taken as a starting-point.

COST OF DOMESTIC HEATING.

Anthracite v. Gas.

The Engineering Supplement to "The Times" recently contained the following letter by Mr. J. D. Hamilton Dickson, of Peterhouse, Cambridge, in reply to previous correspondence that arose out of Mr. Darling's series of Cantor Lectures at the Royal Society of Arts—*ante*, p. 125.

I note that Mr. Darling explains that his calculations are in the main theoretical, being based upon "assumptions" and "efficiencies," probably fair in general. Mr. Goodenough merely states that the gas consumption "would not exceed" and "ought not to average more than." But such mere statements produce no conviction. He advises me to make another experiment which I may "quote with the *certainty* of *accurately* representing the position to-day" (the italics are mine). My experiment, although not made "to-day," is only two years old. It extended continuously for six weeks; the content of the room was given; I was advised by a representative of the local Gas Company that an open gas-fire consuming 25 cubic feet per hour would suffice. I found it quite inadequate; and the same adviser put in for me a larger fire with considerably increased gas consumption. It was still quite inadequate. From this experiment with the second gas-fire I found the consumption stated in my letter (March 1, 1911), which worked out at 52½ cubic feet per hour. These are facts which with "certainty" "accurately" represent my position. It falls on Mr. Goodenough to produce, in a similar manner, facts that "to-day" reduce my 52½ to his 31 or 25 cubic feet.

But let us accept his numbers, and say the consumption is halved. Then the cost of the unsatisfactory gas heating will work out from my 1911's at value 23·52d. for a week of seven days of four hours each. On the other hand, the completely satisfactory anthracite stove, which maintained a room at about 60° Fahr. in the coldest time of the year for a week of seven days of 24 hours each, cost 27·30d. Thus even with Mr. Goodenough's value I am entitled, in order to institute a comparison, to reckon a four-hours' consumption (surely this is fair, out of 168 consecutive hours), which gives only 4·55d. for the anthracite stove—showing it to be, even now, over five times more economical than Mr. Goodenough's imagined gas-fire of to-day. Note that here I have taken no account of the fact that (possibly due to mild weather) this anthracite stove has this winter only been consuming two-thirds of the 1911 amount.

Now I take Mr. Goodenough's other test—"the more economical for practical use, year in, year out." From my 1911 letter, gas-fire and light for 28 days, Nov. 9 to Dec. 7, consumed 306·84 − 298 80 = 8·04 thousand cubic feet. In the 14 days, Dec. 7 to Dec. 21 (more severe on the light, and therefore favouring the gas-fire), the consumption for

light alone was 307·92 − 306·84 = 1·08 thousand cubic feet. Subtracting double this (for 28 days) from 8·04 leaves 5·88 thousand cubic feet of gas used in the gas-fire from Nov. 9 to Dec. 7, which at 2s. 8d. per 1000 cubic feet costs 15·68s. The anthracite stove from Feb. 2 to Feb. 20, 1911, consumed 3 cwt. of coal at 39s. per ton; costing therefore 5·85s. The gas heating was quite inadequate; the anthracite heating was quite adequate. "Which is the more economical for practical use"—15·68s. for 28 days inadequate gas heating, or 5·85s. for 18 days (9·10s. for 28 days) satisfactory anthracite heating? These are total costs for the periods in question, therefore "practical."

It is quite possible that Mr. Dale's "own experience" of 42½ cubic feet of gas may tally with my 52½ cubic feet, for he gives it as "the general average consumption," not stating the contents of the rooms heated, nor the temperatures attained, nor how the temperatures varied during 24 hours.

Mr. Goodenough aims at making a point by saying that the heating need not be continuous in several cases. To-day I have made a nine-hours' set of observations on the anthracite stove. From 1.40 till 2.40 p.m. the readings were taken every five minutes; from 2.40 till 7 p.m. they were taken every half hour. [I used the outside and inside min.-max. thermometers.] At 10 a.m. the regulator was put full off and the window was opened. At 1.40 p.m. the regulator was put half on—outside temperature 37° Fahr., inside 59° Fahr. At 2 o'clock the regulator was put full off—outside temperature 37°, inside 62°. At 3 o'clock, the outside temperature began to fall, and fell steadily to 28° at 7 o'clock. During the same period (3 to 7 o'clock), the inside temperature fell from 61° to 59°. At 7.30 (window closed), the regulator was put half on; and by 8 o'clock, notwithstanding the outside drop of 9°, the room was again at 62°. From 2 till 2.30 o'clock, the convection current from the stove (regulator off) remained above 120°, after which it fell slowly to 81° at 7 o'clock. This shows the great value of continuity, and how eminently the stove utilizes its heat—a process not possible with any open gas-fire. When the gas-fire is turned off, its chimney acts as a remover of heat from the room, instead of a further supplier of heat to it; and the want of continuity which is claimed as an advantage for a gas-fire is really one of its greatest disadvantages. Count Rumford, on the very point, says, textually [Essay vi., chap. 2]: "As only that part of the air which, entering the fire place in a proper manner, and in a just quantity, and coming into actual contact with the burning fuel *is decomposed*, contributes to the generation of heat, it is evident that all the air that finds its way into the fireplace, and *out of it again*, without being decomposed, is a thief—that it not only *contributes nothing* to the heat, but, being itself heated at the expense of the fire, and going off *hot* into the atmosphere by the chimney, occasions an actual loss of heat; and this loss is often very considerable, and the prevention of it is such an object that too much attention cannot be paid to it in the construction of fireplaces." [Italics are Rumford's.]

I disagree entirely with much else that Mr. Goodenough puts forward as pleas for gas-stoves—for instance, the "efficient flue" (dealt with by Count Rumford already), the "radical hygienic error of heating the air" (a perfect mystery, but again such heating was strongly urged both by Count Rumford and Sir William Siemens), and trivial little matters like cleaning the grate and carrying the coals, and the fire being out just when wanted (my stove has burned continuously from Sept. 28 till now), &c. But I refrain, for the sake of space, to refute these points. I should like, however, to refer to the sentiment of which gas supporters are so fond. When a peace, retrenchment and reform Government in six years raises the National Budget from 140 to 200 million pounds, the middle classes have got to do without the "sentiment" they were able to afford in easier times, and have to hand the money spent on it to the tax man instead.

The following reply by Mr. Goodenough to the preceding letter appeared in the Engineering Supplement to "The Times" last Wednesday.

Mr. Hamilton Dickson has not realized that the efficiency of gas-fires, like their design, has improved materially in the short period of two years that has elapsed since his experiments. That is why I suggest that the results he observed two years ago do not necessarily represent those which he would obtain to-day.

I evidently, however, failed to make clear to him the basis of my contention that heating by gas is in many cases more economical for practical use, year in year out, than bituminous coal anthracite, or coke. I do not base that contention on the comparative costs of one gas-fire against one coal grate or stove, hour by hour, or even week by week, used in a room which it is desired to heat daily for hours on end. In the case of continuous heating—as I thought would clearly be inferred from my letter—the direct cost of gaseous fuel at usual prices is greater than that of solid fuel. Where heat is required only spasmodically—as in the case of billiard-rooms, bedrooms (when not sick-rooms), studies, and the like—not only is the direct cost of heating by gas less than that of heating by solid fuel, but it is possible to secure warmth just as and when required without making any addition to the work of the household.

Mr. Hamilton Dickson may refer to the cleaning of grates and the carrying of coals as "trivial little matters;" but there are few mistresses of households who, confronted as they constantly are by the domestic servant problem, will be found to endorse that description. I could give him many an instance of households where, owing to the exclusive use of gas for fuel, the mistress (of a class far above the artizan) does all the work herself with the aid of the occasional charwoman. I could point him to many homes where two servants now with ease carry on the household work which kept three well employed before coal gave way to gas as the sole fuel employed—and a servant's wages and keep represent at least £50 a year. I could refer him to mistresses who keep comprehensive household accounts, who would tell him that not only have they saved wages but also found material economies effected in their laundry and repair bills through the greater cleanliness of gaseous firing. I could instance a well-known nursing home where, owing to the adoption of gas throughout for heating, the saving in wages and keep more than paid the gas bill; while the amount represented by the former heavy coal bill was added to the profits of the establishment. That is why I am obliged to regard the figures which Mr. Hamilton Dickson considers conclusive as only a very small factor in a problem that is wider than he appears to have realized.

Again, the likelihood of a coal-fire being out just when wanted may appear to Mr. Hamilton Dickson as "a trivial little matter;" but it did not so present itself to a friend of mine, whose child's death was directly occasioned by the dying-out of a coal-fire while an over-tired nurse unintentionally slept.

My reference to the "radical hygienic error of heating the air of (instead of the objects in) a room" is "a perfect mystery" to Mr. Hamilton Dickson. I must refer him to the address of the President of the Physiology Section of the British Association at Dundee last year for a full explanation of that, to him, mysterious phrase. I will only explain here briefly that I was contrasting Nature's method of heating—*i.e.*, by the rays of the sun, which heat the objects on which they fall, not the air through which they pass, as witness shade and sun thermometers within a few inches one of the other—with such methods of artificial heating as raise the temperature of the air, and so increase its capacity for moisture, with the consequent unpleasantness one experiences in over-heated railway carriages and many buildings heated by convection instead of radiation. I should have liked to go further into this interesting subject, which is at present attracting no little attention among those interested in the hygiene of heating and ventilation, if space had permitted.

On the question of flues, and Mr. Hamilton Dickson's remark that "when a gas-fire is turned off its chimney acts as a remover of heat from the room instead of a supplier of heat to it," I would only point out that a gas-fire is usually turned off only when heat is no longer required, and that the continued ventilating effect resulting from the "pull" of a warm chimney is usually regarded by hygienists as distinctly an advantage, and not a drawback to the system of open-fire heating, whether the open fire be a purified gas or an unpurified gas (*i.e.*, a coal) fire.

LARGE GAS-ENGINE PLANT IN FRANCE.

The following particulars in regard to the use of large gas-engines in France were given in a recent number of the "Electrician."

Within the last few years, there has been marked progress in the use of high-power gas-engines in Europe, especially in blast-furnace works where the waste gases from coke-ovens can be used directly in the engine, instead of being burnt under boilers to produce steam. One of the newest gas-engine plants has been erected in the North of France, at the Lens mining and metallurgical works. This firm recently built 160 new coke-furnaces, and it was decided to use the gas from them to operate large-size engines, and thus secure a considerable amount of power. Two separate methods of utilization are employed. In one the gas heats boilers, steam from which is supplied to a large steam-turbine plant; in the other, the gas serves directly to operate gas-engines. When completed, the latter plant will consist of six generating sets, each of 1200 H.P. capacity. They will furnish all the current required in the works for operating electric motors and for the lighting.

The gas from the coke-furnaces, which are of the Koppers recuperative type, is transmitted by blowers to a set of four scrubbers, whence it passes to a gasholder of 15,000 cubic feet capacity. This latter is designed as a reserve supply, and the engines can be run from it for half-an-hour in case the gas should give out. The type of engine used is double-acting, and works on the four-cycle principle. Two cylinders run in tandem; the speed being 107 revolutions per minute. The engine is started by compressed air, and electric ignition is employed. On the engine-shaft is mounted a three-phase alternator and a 27-ton fly-wheel. For the ignition, two 60-volt storage batteries are employed; these being charged by machines in the basement. One battery is in use while the other is being charged. A three-phase motor coupled to an air-compressor provides a compressed-air supply, and feeds a pair of charging-tanks. The alternators are of the rotating field type, and are designed to furnish 1000 kilowatts at 5000 volts and a frequency of 50. Two motor-generator groups serve as exciters; each group being capable of supplying the three alternators. A 100 H.P. non-synchronous motor, working on the 200-volt circuit, is employed for driving the generator of the group, and its speed is 970 revolutions per minute. Current is obtained from 100-kilowatt oil-cooled three-phase transformers, two of which supply the motors, and a third the lighting and ignition.

CHEMICAL MANUFACTURERS AND THE GAS INDUSTRY.

The Engineering Supplement to "The Times" last Wednesday was devoted mainly to a review of engineering and allied matters in the past year. The following remarks were made on the subject of the action taken by the chemical manufacturers on the residuals questions.

During the past ten years, the great increase in motor traffic has made the introduction of some method of preventing the dust nuisance an absolute necessity. Tar, employed as a coating, as tar macadam or for grouting, has proved to be by far the most suitable material; and a large demand has sprung up all over the country for prepared tar for this purpose. It has been found that if raw tar were employed, the surface of the road disintegrated rapidly, and gave rise to black mud and contamination of the neighbouring watercourses. To be used successfully, the tar must be prepared by driving off all the water, and distilling off the light oils. At first the local authorities obtained such prepared tar from the tar distillers; but eventually they discovered that it could be obtained far more cheaply from many of the gas-works which were willing to give the tar a preliminary boiling. The demand increasing rapidly; the tar distillers found themselves confronted with a shortage of tar; and prices, which had been ridiculously low, began to rise. The increased working-up of ammonium sulphate also by about one-half of the gas-works in the country began to affect the

chemical manufacturers to a certain extent, and when a few of the largest gas-works began to use the spent oxide from the sulphuretted hydrogen purifiers for making sulphuric acid to work-up the ammonium sulphate, the tar distillers and chemical manufacturers combined to ask Parliament to place restrictions upon gas companies in inter-dealing with each other in such residuals—that is to say, if a gas undertaking liked to work-up these residuals, it should be free to do so, but it should be debarred from purchasing residuals from other undertakings to work-up with its own.

Before Parliament realized the meaning of such a restriction, a clause to this effect was introduced in two or three Bills, and a model clause was drafted; and had not the gas companies suddenly awakened to the fatal effect of such a measure, it would probably have been introduced into all future Bills. The Gas Companies' Protection Association, however, petitioned Parliament on the subject; and a Joint Committee of the two Houses held an inquiry into the matter, with the result that they declined to impose any restrictions as to inter-trading between gas companies in their own residuals.

The importance of this decision to the gas companies is of the most far-reaching character as regards the future, because if gas is to continue its steady progress in popularity as a fuel, everything that can be done to lead to its cheapening should be striven for. Inasmuch as the increase in the cost of raw materials and labour is tending rather in the opposite direction, every economy, no matter how small, becomes an important factor; and it is really upon the residuals that in the future the gas manager will have to depend for any possible cheapening of the gas.

Given cheap gas and good coke, there is no reason why the domestic fuel supply of the country should not in time be treated in the gas-works, and so benefit the community by the abolition of smoke. But if the gas companies had been trammelled by any restrictions in the working-up of the residuals, the market for them would have been thrown into the hands of the tar distillers and chemical manufacturers, and the price of residuals would undoubtedly have fallen instead of, as now will be the case, being kept up by competition between the gas-works and the chemical trades. Probably, the brightest memory of the gas industry in 1912 will be the winning of this victory.

FUSINGS AND FIRES AT REDRUTH.

There has been an inquiry conducted by the Fire Committee at Redruth into the circumstances connected with a recent fire; and a report of the investigation was presented at the last meeting of the Urban District Council.

In bringing the matter forward, Mr. Trestrail said that, as a Council, they knew fires were a long way too prevalent in the district; and though he was not speaking from statistics, fires, during the past few years, had been more numerous than they were formerly. After the fire at West End (the subject of the inquiry), the Mining Schools very nearly caught alight; the outbreak being accidentally discovered by a builder on the roof. The Fire Brigade found that an electric wire had fused, that the wire was in a wooden casing, and that the casing had been charred for a considerable length. The gas-pipe close to the wood melted away. He considered that it was dangerous for such wires to be in wooden casings. When the wires fused, the wood must be set on fire; and where the wires were in wooden casings, the people would appear to be living in a "fool's paradise." If he lived in a house where the wire was in a wooden enclosure, he should not sleep very comfortably. He did not mention the matter as a slight to anyone who might be responsible; but he would have thought that the Board of Trade would have supervised such matters, and surely the insurance companies were cognizant of the facts. He thought the Council should pass a resolution calling the attention of the Urban Electric Supply Company to this method of wiring buildings; and he moved to this effect. It was not through any spleen or desire for criticism that he brought the matter forward; but he thought the general public were, perhaps, in the dark as to the consequences that might arise through wires being in wooden casings, instead of in metal piping.

Mr. Kistler, in seconding, said they had had more than one instance in the past of the fusing of wires; and one of their members (Mr. Michell) must remember the narrow escape his premises had. This outbreak occurred when Mr. Michell was about to leave his shop; and had it happened after he had left, there would have been no possible chance of saving the three next buildings. As a Council, they were not there to censure the Electric Supply Company, but to protect properties that might suffer through the fusing of wires in wooden casings. He believed that if the attention of the Company was called to the matter, they would do everything possible to find a remedy. The Council must point out to the Company that they had a duty to perform; and he was sure the Company would recognize it.

Mr. Launder said the Electric Supply Company were evidently taking this matter into consideration; for at the last place he saw them installing the light, they were placing the wires in iron tubing.

The resolution that the attention of the Urban Electric Supply Company be called to the placing of electric wires in wooden casings was unanimously carried.

Failure of Electric Light in the Blackpool Post Office.—On Monday evening last week, business in the General Post Office at Blackpool was considerably interfered with owing to the failure of the electric light. About a quarter past five the staff and those members of the public who were in the building were startled to find all the lights go out. As the current did not return, a supply of candles was obtained; and these were distributed about the various counters. For the next two-and-a-half hours the business was transacted by their aid; but about eight o'clock the electric light was restored. The whole of the large building was affected by the failure, the cause of which was stated to be the fusing of the main switch.

NOTES FROM SCOTLAND.

From Our Own Correspondents.

Saturday.

The visit of the Western Juniors to Pumpherston proved as interesting as was predicted by the Hon. Secretary, Mr. Fulton, and was very well attended, despite the early start. The absence of workmen, although the works were in full swing, was much remarked upon—in fact, the place seemed to be running itself, so smoothly was everything working. There were lessons for all, but especially for those who are engaged in works having vertical retorts. The large quantity of low-pressure steam which serves to carry off some of the nitrogen from the coke and turn it into ammonia also keeps the heats of the retorts from damaging the oil for which the works are primarily carried on. The steam also serves to cool the shale residue, or what would be coke in gas-works. The retorts are circular; and there seems every reason for the adoption of this section for verticals, as the heat will be then radiated from the sides directly towards the centre of the mass of coal, and so make the heat travel through the mass evenly. It has also been found that with rectangular retorts, even when they have the corners rounded, there are pockets formed, up which the gases travel instead of through the coke. Here also we had the lesson that the residuals paid the dividend; and while there was nothing extraordinary to gas makers, everything seemed to be utilized. From one ton of shale there will result about 24 gallons of oil, from which petrol, paraffin wax, and burning and lubricating oils will be distilled, 45 lbs. of sulphate, and a residue of 80 per cent. of spent shale. Curiously enough, the best-paying residual is the wax, from which candles are made, although it would have been thought that the candle-making industry had almost departed. The condensers consist of a number of small pipes set in high batteries; and it is a wonder that this type is not more utilized in gas-works, as there is no doubt that they are efficient, as the condensate is what the oil-works people desire most. It was at these works that tests were made for Mr. Herring. The retort used by him was shown; and it was reported that no difficulty had occurred in working these retorts for the making of gas instead of oil. The heat value of the residual gas from the oil-making process is much lower than would have been anticipated; being only 150 B.Th.U. per cubic foot. No doubt this is due to the introduction of the steam already referred to.

Aberdeen.—The Gas Committee of the Town Council have agreed to place an order for new carbonizing plant for their works provided certain conditions are agreed upon by the contractor. The estimated cost is £15,000.

Ayr.—It is interesting to note that the electricians have agreed to raise their prices. This is being done owing to the increase in the cost of coal, which amounts to 33 per cent. The Lighting Committee have recommended that the private lighting rate be raised from 2½d. to 4d. per unit, with a reduction to large consumers, and that for public lighting 2½d. should be charged in place of 2d. The rate for the tramways to be as before, and the current for heating and cooking to be supplied at the reduced rate—from 1½d. to 1d.

Dunbar.—Estimates, amounting to nearly £20,000, are being invited by the Town Council in connection with work for the augmentation of the water supply.

Falkirk.—An explosion took place in the manholes over the electric cables in Gortcows Road, by which two of the covers, which are of heavy metal and cement, were forced into the air, together with several pieces of pavement. The explosion is attributed to the accumulation under the manholes of gas which had by some means or other become ignited. The installation of the high-pressure lighting system is now complete; and Mr. Wilson, the Gas Engineer and Manager, has reported the fact to the Gas Committee, and asked them to examine it. The Town Clerk reported that he had received from the Town Clerk of Glasgow a letter regarding the cost of opposing the application of residual products makers before a Joint Committee of the two Houses of Parliament, and asked for a contribution from Falkirk in accordance with their make. It was decided to contribute a sum not exceeding £5. Treasurer Wallace reported that the Insurance Company had settled the claim arising out of the recent explosion of the condensers; and it was agreed to take out an inclusive policy for the whole works.

Glasgow.—A case of gas poisoning, which fortunately did not have fatal results, occurred on Sunday. It was found that the escaping gas had occurred in the flat below, which was at the moment unoccupied, and in which the gas-pipes had been disconnected at the meter.

Grangemouth.—The Gas Manager reported to the Town Council that one of the ovens in the retort-house had collapsed, and that there had been great difficulty in keeping up the supply of gas. A Committee was appointed, consisting of Provost Main and Councillors Cloag and Sharp, with powers to arrange regarding the retorts, to report upon the capacity of the gasholder, and as to increasing the main in one part of the district.

Greenock.—At the last Corporation meeting, the question of the supply of electric light to Port Glasgow was raised, owing to the Port Glasgow School Board having lodged an objection to the Electric Lighting Order presented by the Port Glasgow Town Council for the supply of electricity to power users and others from the Greenock Corporation. The matter was left in the hands of the Sub-Committee to deal with. Complaints were raised as to the quality of the gas; but Bailie Taylor, the Convener of the Gas Committee, pointed out that the gas was of the same quality as that supplied by 53 gas companies in the United Kingdom, as it was approximately 17-candle power. The reduction from 20 candles (the former standard) was owing to the change in the requirements, due to the change of methods of consuming the gas, as at the present time 85 per cent. of the consumers were using gas for heating or manufacturing, and for this purpose 17-candle gas was better suited than that of 20-candle power. He referred to the great increase during the past six months in the consumption of gas, and stated that it would soon be necessary for the Committee to ask for a new installation of retorts to deal with the large increase.

CURRENT SALES OF GAS PRODUCTS.

Sulphate of Ammonia.

LIVERPOOL, *Jan.* 25.

During the past week the demand for this material has hardly been so good as that recently experienced, dealers having apparently covered their requirements for January shipment, and direct buyers having also not been so much in evidence. Consequently the tone of the market has been rather less firm, and the closing quotations are £14 7s. 6d. per ton f.o.b. Hull, £14 8s 9d. per ton f.o.b. Liverpool, and £14 10s. per ton f.o.b. Leith. There is not much business passing in the forward position, purchasers showing little disposition to operate at the figures required; but manufacturers continue to maintain a very firm attitude, and ask 2s. 6d. to 5s. per ton premium on prompt prices.

Nitrate of Soda.

The market for this article is dearer, and the quotations on spot have been advanced to 11s. 10½d. per cwt. for ordinary and 12s. for refined quality.

LONDON, *Jan.* 27.

Tar Products.

There is not much alteration in the market for tar products; but on the whole prices keep steady. Pitch maintains its quotation. There is a fair amount of inquiry for both prompt and forward delivery. Benzols are quiet for prompt. There has been a little more inquiry for forward; but business is very difficult to negotiate owing to the high prices being asked. Business is very quiet in solvent naphthas, and sales are reported at slightly lower figures. Heavy naphtha remains fairly steady. Creosote is still in good demand, and further contracts are reported. Contracts are very difficult to arrange in crude carbolic. There is still a margin of 1d. to 2d. a gallon between buyers and sellers.

The average values during the week were: Tar, 29s. 9d. to 33s. 9d. Pitch, London, 47s. 6d. to 48s. 6d.; east coast, 47s. to 48s.; west coast, Clyde, 47s. to 47s. 6d.; Manchester, 45s. to 46s.; Liverpool, 45s. 6d. to 46s. 6d. Benzol, 90 per cent., naked, London, 10¾d. to 11d.; North, 9¾d. to 10d.; 50-90 per cent., naked, London, 10¾d. to 10⅞d.; North, 9½d. to 10d. Toluol, naked, London, 10¾d. to 11d.; North, 10d. to 10½d. Crude naphtha, in bulk, London, 5¼d. to 5⅜d.; North, 5d. to 5⅛d. Solvent naphtha, naked, London, 1s. 1d. to 1s. 1½d.; North, 1s. 1d. f.o.b. Heavy naphtha, naked, London, 11½d. to 1s. f.o.b.; North, 10½d. to 11d. f.o.b. Creosote, in bulk, London, 3¼d.; North, 3⅛d. to 3¼d. Heavy oils, in bulk, 3¼d. to 3⅜d. Carbolic acid, casks included, 60 per cent., prompt, east and west coasts, 2s. 1d. to 2s. 2d. Naphthalene, £5 to £9; salts, 45s. to 50s., bags included. Anthracene, "A" quality, 1½d. to 1¾d. per unit, packages included and delivered.

Sulphate of Ammonia.

Although the market has remained fairly steady during the past week, there has not been very much new business. However, tender parcels have in each case fetched fairly good prices; and manufacturers still maintain their attitude as regards the forward position. Actual Beckton is quoted at £14. Outside London makes are £13 15s.; Leith, £14 10s. to £14 11s. 3d.; Liverpool, £14 10s.; Hull, £14 8s. 9d.; Middlesbrough, £14 8s. 9d.

Manchester District Tar Prices.

It is officially announced that the average price realized for December deliveries of tar in the Manchester district—based on the value of the products—was 37s. 4d. per ton.

GAS COMPANIES' STOCK AND SHARE LIST.

Things on the Stock Exchange last week were naturally dominated by the momentous events of that period which go to make European history. The week had well advanced, with daily strengthening prospects of peace in the East, when a bolt from the blue fell in the form of the Constantinople *coup d'état*, which plunged everything into confusion worse confounded. As if this were not enough, an Ossa of confusion is heaped on Pelion by the state of muddle that we here are in over the Franchise Bill. It is no wonder then if the boldest operators pause awhile and preserve masterly inactivity. The opening day was dull and spiritless; and markets weakened generally. Government issues receded, and Consols fell ¼. Rails were flat on disappointing dividends, and Americans were dull. But Tuesday was better—the political outlook seeming brighter. Consols regained ¼, and Rails showed some improvement; while the Foreign Market was firm Wednesday had quite a cheerful tone, and business was smarter. All the chief markets showed a stronger front. Thursday began under the continuing influence of the day before; but after a while the cheerfulness abated. Still most markets effected some advance. Consols improved ¼. On Friday everything was much perturbed by the Constantinopolitan news, and fell very flat. Now and then a fitful show of steadying was made; but it could not stay. Consols went down ¼. On Saturday, business was as quiet as possible; the general attitude being one of watchful abstention from further commitments until the horizon cleared somewhat. Consols were rather weaker, losing ⅛ for account, and closing at 74⅜ to 75—a loss of ⅛ in the week. The Money Market was very firm. The demand for short loans was persistent; and discount rates hardened steadily. Business in the Gas Market was a good fair average in point of volume, though scarcely equal to the week before. The tendency throughout was quite favourable; several quotations showing an advance. Gaslight and Coke maintain the rate of dividend paid six months ago, though not without recourse to the balance then carried forward. The spring-like December was not conducive to a large output of gas. The ordinary stock was fairly active and quite strong at 107¼ to 108¼—a rise of 1. In the secured issues, the maximum was done at 83½ special to 84⅜, the preference at 101¼, and the debenture at 77. South Metropolitan was strong and active, realizing from 117⅛ to 118½ (a rise of 1); the debenture marking 75½ and 76¼. In Commercials, the 4 per cent. changed hands at 108, the 3½ per cent at 103⅜ to 104, and the debenture at 73. Among the Suburban and Provincial group, Brentford old fetched 261, ditto new 200 and 201 (a rise of 2), British debenture 90¾, South Suburban 119 and 119½, Tottenham "B" 117, Wandsworth debenture 69, and (on the local Exchanges) Newcastle 102, and Liverpool debenture 99. In the Continental companies, Imperial marked from 174¼ to 175½, ditto debenture 88¼, Union from 84 to 86, and European from 18⅝ to 18⅞. Among the undertakings of the remoter world, Cape Town preference was done at 3⅜, Monte Video at 12 11/16 and 12¾, Primitiva at 6⅜ to 6⅝, and ditto preference at 5 3/32 to 5¼.

Issue.	Share.	When ex-Dividend.	Dividend or Dividend & Bonus.	NAME.	Closing Prices.	Rise or Fall in Wk.	Yield upon Investment.
£			p.c.				£ s. d.
1,551,868	Stk.	Oct. 11	5	Alliance & Dublin Ord.	73—78	..	6 8 2
374,000	,,	Jan. 16	4	Do. 4 p.c. Deb.	81—84*	..	4 15 3
280,000	5	Oct. 11	7½	Bombay, Ltd.	6½—7	..	5 7 2
50,000	10	Aug. 29	15	Bourne- mouth Gas & Water	10 p.c.	..	5 0 0
332,000	10	,,	7		B 7 p.c.	..	4 6 2
75,000	10	,,	6		Pref. 6 p.c.	..	4 2 9
380,000	Stk.	Aug. 14	13½	Brentford Consolidated	257—262	..	5 3 1
830,000	,,	,,	10½	Do. New	200—205	+2	5 2 5
50,300	,,	,,	5	Do. 5 p.c. Pref.	116—118	..	4 4 9
206,250	,,	Dec. 12	4	Do. 4 p.c. Deb.	94—96	..	4 3 4
218,230	Stk.	Aug. 29	14	Brighton & Hove Orig.	210—215	..	5 2 4
244,200	,,	,,	8	Do. A Ord. Stk.	152—155	..	5 3 3
530,000	20	Sept. 27	12½	British	44½—45½	..	5 9 11
120,000	Stk.	Dec. 30	4	Do. 4 p.c. Deb. Stk.	99—91	..	4 7 11
245,771	Stk.	,,	4	Buenos Ayres 4 p.c. Deb.	92—94	..	4 5 1
100,000	10	—	—	Cape Town & Dis., Ltd.	2—3	..	—
150,000	10	—	—	Do. 4½ p.c. Pref.	3½—4½	..	—
100,900	Stk.	Dec. 30	4½	Do. 4½ p.c. Deb. Stk.	71—75	..	6 0 0
157,150	Stk.	Aug. 29	5	Chester 5 p.c. Ord.	110—112	..	4 9 3
1,513,280	Stk.	Aug. 29	5/9/4	Commercial 4 p.c. Pref.	106—108	..	5 1 2
660,000	,,	,,	5½	Do. 3½ p.c. do.	102—104	..	5 2 6
475,000	,,	Dec. 12	3	Do. 3 p.c. Deb. Stk.	71—73	..	4 2 2
800,000	Stk.	,,	4	Continental Union, Ltd.	83—86	..	4 13 0
200,000	,,	,,	7	Do. 7 p.c. Pref.	130—132	..	5 6 1
492,270	Stk.	—	5⅝	Derby Con. Stk.	124—125	..	4 12 0
55,000	,,	—	4	Do. Deb. Stk.	103—105	..	3 16 2
1,003,120	10	Jan. 16	10	European, Ltd.	18½—19½*	..	5 2 7
16,160,600	Stk.	Aug. 14	4/17/4	Gas light and Coke	4 p.c. Ord.	..	4 9 4
2,600,000	,,	,,	3½		3½ p.c. max.	..	4 2 4
4,062,235	,,	,,	4		4 p.c. Con. Pref.	..	3 18 5
4,531,705	,,	Dec. 12	3		3 p.c. Con. Deb.	..	3 17 11
258,740	Stk.	Sept. 13	5	Hastings & St. L. 3½ p.c.		..	5 7 6
82,500	,,	,,	6½	Do. do. 5 p.c.	—	..	—
70,000	10	Oct. 11	11	Hongkong & China, Ltd.	16—16½	..	6 13 4
131,000	Stk.	Sept. 13	7⅞	Ilford A and C	154—157	..	4 17 1
65,780	,,	,,	6⅛	Do. B	122—124	+1	4 18 9
65,500	,,	Dec. 30	4	Do. 4 p.c. Deb.	89—91	..	4 7 11
4,940,060	Stk.	Nov. 14	9	Imperial Continental	173—178	..	5 1 1
1,235,000	Stk.	Aug. 14	3½	Do. 3½ p.c. Deb. Red.	87—89	..	3 18 8
200,242	Stk.	Aug. 29	6	Lea Bridge Ord. 5 p.c.	122—125	..	4 16 0

Issue.	Share.	When Dividend.	Dividend or Dividend & Bonus.	NAME.	Closing Prices.	Rise or Fall in Wk.	Yield upon Investment.
£			p.c.				£ s. d.
561,000	Stk.	Aug. 29	10	Liverpool United A	223—225	..	4 8 11
718,100	,,	,,	7	Do. B	161—163	..	4 5 11
306,083	,,	Dec. 30	4	Do. Deb. Stk.	98—100	..	4 0 0
63,480	Stk.	Jan. 16	3	Maidstone 3 p.c. Deb.	68—70*	..	4 5 9
75,000	5	Nov. 28	6	Malta & Mediterranean	4¼—4¾	..	6 6 4
250,000	100	Oct. 1	4½	Met. of Melbourne	4½ p.c. Deb.	99—101	..	4 9 1
541,920	20	Oct. 30	3½	Monte Video, Ltd.	12¼—12¾	..	5 9 10
1,775,892	Stk.	July 26	4⅝	Newc'tle&G'tesh'd Con.	101½—102½	+1	4 5 4
529,705	Stk.	Dec. 30	3½	Do. 3½ p.c. Deb.	86—87	+½	4 0 6
55,940	10	Aug. 29	7/7/0	North Middlesex 7 p.c.	13½—14½	..	5 1 5
300,000	Stk.	Nov. 28	8	Oriental, Ltd.	125—130	..	6 3 1
60,000	5	Sept. 27	10	Ottoman, Ltd.	8¼—8¾	..	5 14 3
60,000	50	Aug. 14	13	Portsea, Island B	127—130	..	5 0 0
100,000	50	,,	12	Do. C	124—127	..	4 14 6
249,980	5	Oct. 11	8	Primitiva Ord.	6¼—6⅜	..	5 18 6
499,960	5	Dec. 30	5	,, 5 p.c. Pref.	5—5¼	..	4 15 3
521,600	100	Dec. 2	4	,, 4 p.c. Deb.	96—98	..	4 1 8
346,198	Stk.	Dec. 30	4	River Plate 4 p.c. Deb.	92—94	..	4 5 1
275,000	5	Apl. 12	12	San Paulo, Ltd.	13—14	..	4 5 9
150,000	10	Sept. 27	6	Do. 6 p.c. Pref.	11½—12	..	5 0 0
125,000	50	Jan. 2	5	Do. 5 p.c. Deb.	49—51	..	4 18 0
135,000	Stk.	Aug. 29	10	Sheffield A	232—234	+1	4 5 6
209,984	,,	,,	10	Do. B	233—234	+2	4 5 6
523,500	,,	,,	10	Do. C	229—231	..	4 6 7
90,000	10	Sept. 27	7½	South African	9½—10½	..	7 2 10
6,429,895	Stk.	Aug. 29	5/9/4	South Met., 4 p.c. Ord.	117—119	+1	4 11 9
1,895,445	,,	Jan. 16	3	Do. 3 p.c. Deb.	74—77*	..	3 17 11
209,820	Stk.	Aug. 14	8½	South Shields Con. Stk.	164—166	..	5 2 5
605,000	Stk.	Aug. 14	5/16/8	S'th Suburb'n Ord. 5 p.c.	118—121	..	4 16 3
60,000	,,	,,	5	Do. 5 p.c. Pref.	117—119	..	4 4 0
117,058	,,	Dec. 30	5	Do. 5 p.c. Deb. Stk.	118—120	..	4 3 4
594,740	Stk.	Nov. 14	5	Southampton Ord.	102—105	..	4 15 3
120,000	Stk.	Aug. 14	7½	Tottenham A 5 p.c. and B 3½ p.c.		142—145	..	5 0 0
483,940	,,	,,	5½			115—117	..	4 18 3
149,470	,,	Dec. 30	4	Edmonton 4 p.c. Deb.		92—94	..	4 5 1
182,380	10	,,	5	Tuscan, Ltd.		8—8½	..	5 17 8
149,900	10	Jan. 2	5	Do. 5 p.c. Deb. Red.		96—98	..	5 2 0
236,476	Stk.	Aug. 14	5	Tynemouth, 5 p.c. max.		115—115½	..	4 6 7
255,636	Stk.	Aug. 29	6⅞	Wands- worth	B 3½ p.c.	140—143	+1	4 16 2
85,766	,,	Dec. 30	3		3 p.c. Deb. Stk.	68—70	..	4 5 9

Prices Marked * are "Ex. Div."

COAL TRADE REPORTS.

Northern Coal Trade.

There is now a fuller demand for coal; and with steamers more plentiful at the coal ports, the shipments are heavier. Prices are, therefore, firm. In steam coals, best Northumbrians are steady at 15s. 3d. to 15s. 6d. per ton f.o.b. for prompt delivery, with easier prices for forward. The production is now about normal, and is well taken up; while some large contracts are in the market. In the gas coal trade, with renewed demand from the Mediterranean, there is more activity both for home and foreign use. The output is well bespoken, though much of it is on long contracts at prices lower than those now ruling. Current quotations are based on from 15s. to 15s. 6d per ton f.o.b. for best Durham gas coals. Second-class gas coals are about 14s. 6d. per ton; and for "Wear" specials, the price quoted is somewhere about 16s. to 16s. 3d. per ton f.o.b. There are inquiries for gas coal for Genoa for the next few months. For best Durhams, about 26s. 3d. to 27s. per ton, delivered, are prices that are quoted for next month; while for second-class gas coals, delivered, from 24s. 6d to 25s. is asked for the next three months. Buyers, however, do not readily concede such figures, which might be influenced by changes in the rate of sea freight—the current freights being 2s. 3d. per ton lower than those of three months ago. Coke is generally firm. Good gas coke is scarcely so plentiful, and is steady at 20s. to 21s. 6d. per ton f.o.b. in Tyne Dock.

Scotch Coal Trade.

During the past week there has been practically no variation either in respect of demand or in values in the Scotch coal trade. On Friday, the following were the quotations f.o.b. Glasgow: Steam coal, 13s. 6d. to 14s.; splint, 14s. 6d. to 15s.; ell, 13s. to 13s. 6d.; trebles, 13s. 6d. to 14s.; doubles, 13s. to 13s. 6d.; and singles, 12s. 6d. to 13s.

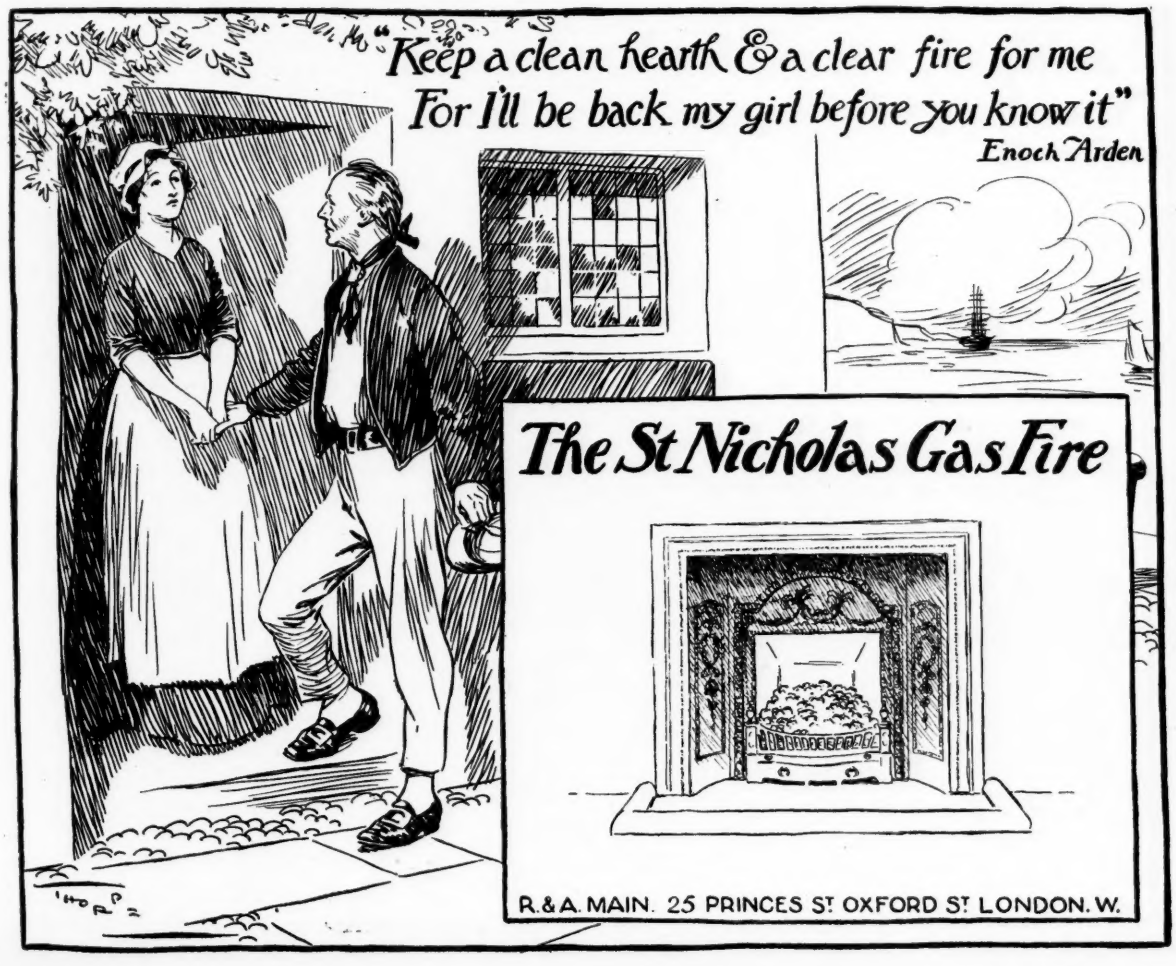
Pudsey Gas Company.—The accounts of this Company for the past year show a balance on the net revenue account of £6328, and a sum of £7329 available for distribution. At the annual meeting next Monday, the Directors will recommend the declaration of a dividend for the six months ended Dec. 31 at the rate of 9 per cent. per annum on the new consolidated 7 per cent. stock; an interim dividend having been paid at this rate in August last. There was a slight increase in the quantity of gas sold in the past year compared with 1911.

Cost of Gas in Tipperary.—The Tipperary Urban District Council recently had before them the provisions of the new Gas Order fixing the maximum price at 4s. 6d. per 1000 cubic feet, *plus* the cost of the hire of meters and fittings. In the course of a discussion, it was stated that consumers who had not bought meters and cookers would pay 5s. 6d. per 1000 cubic feet. Mr. Hanly remarked that the charges were now higher than they were before. It was urged that a public meeting of meter users should be held to consider the question.

Gaslight and Coke Company's Supernumerary Lamplighters.—In the House of Commons, on Monday last week, Mr. Wedgwood asked the Financial Secretary to the Treasury whether the supernumerary lamplighters employed by the Gaslight and Coke Company, and paid at the rate of 5s. 6d. a week, were having 4d. deducted from their wages for the National Insurance; and whether he would have inquiry made as to whether any deduction should be made at all in the case of these men. Mr. Masterman said he had no information with regard to the case referred to in the question; but he was communicating with the Company, and would inform his honourable friend of the result of his inquiry.

Gas v. Electricity for School Lighting.—According to a paragraph in the "Blackpool Gazette," the question of the illuminant to be employed in a new Council school in the borough has lately given rise to a considerable amount of controversy. The members of the Education Committee were circularized on behalf of both gas and electricity; and there promised to be a deadlock when the subject came up at last Tuesday's meeting of an Education Sub-Committee. Eventually, however, gas won the day, but entirely on the ground of initial economy. It was pointed out that the cost of laying a new electricity main to the site of the school would be £100 or more. But as the total lighting bill was not expected to run to more than £20 a year, it was obvious that there would not be much profit for the Electricity Department. On the other hand, a gas installation would be required for cookery and other purposes in which the school is to specialize, and therefore it was decided that the lighting should be by gas also. The total cost of the gas installation (high pressure) was estimated at £250; while wiring and fittings for electricity, with metallic filament lamps, would cost about £470.

Tottenham Public Lighting.—At the meeting of the Tottenham District Council last Tuesday, Mr. Beales proposed that, as the public lighting contract with the Tottenham Gas Company would very shortly expire, application should be made to them to state the terms on which they were willing to renew it for periods of one year, three, five, seven, and ten years; and, further, that the North Metropolitan Electric Power Supply Company should be invited to state on what terms they were prepared to carry out the whole of the public lighting in the district by electricity for similar periods, and to furnish full particulars of their proposals, including the candle power of the lamps they suggested should be provided for the ordinary street lamps. He said the ordinary lamps with a "C" burner had been charged by the Gas Company at £2 12s. 6d. per annum; the power being from 60 to 70 candles. This price was reduced as from the 1st inst. by 1s. 6d. per lamp per annum. His object, in proposing the motion, was to have competition, in order to ensure the lowest possible terms for efficient public lighting. In suggesting various terms of years, he wished to facilitate the Electric Supply Company in giving a fair estimate, having regard to the difficulties and expenditure in providing a supply. The motion was carried without discussion.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Sale of Stocks and Shares.

Messrs. A. & W. Richards resumed their sales of gas and water stocks and shares at the Mart, Tokenhouse Yard, E.C., last Tuesday; and the occasion was one which afforded investors a good opportunity of acquiring an interest in three companies who were issuing new capital. The first lots consisted of £1000 of 4 per cent. perpetual debenture stock and £4000 of new ordinary stock of the Great Yarmouth Water Company. The debenture stock was all sold at par; and the ordinary stock, which ranks for a maximum dividend of 7 per cent., but carries 4 per cent., at £91 per £100. Next came an issue of new ordinary £10 shares in the Southend Water Company. They rank for a maximum dividend of 5 per cent., and carry the same dividend as similar shares—viz, 4½ per cent.; and they fetched £9 10s. each. The third new issue was £2000 of 5 per cent. irredeemable gas debenture stock and £3000 of additional 7 per cent. gas stock of the Sheringham Gas and Water Company. The former was all sold at par; and the latter, which is entitled to 5 per cent. dividend, equally with similar stock, at £92 per £100. By order of executors, some £25 shares (10 and 7 per cent.) in the Dorking Gas Company, carrying 6 per cent., fetched £29 each; a small quantity of 5 per cent. perpetual debenture stock realized £110 per £100; and a few £10 original 10 per cent. shares in the South-West Suburban Water Company, with 7 per cent. dividend, were purchased for £17 2s. 6d. and £17 10s. each.

Theft of Coal from a Gas Company.—At the Stone Police Court, a farmer named John Ainsworth and four youths were charged with stealing a quantity of coal value 15s., the property of the Stone Gas Company. It was stated that the Company's coal came by rail from the Madeley Colliery Company to Cockshutt (Stoke), and then by boat to Stone. For some time deficiencies had been noticed, and one day a boatman was seen to draw a barge alongside Ainsworth's property. Ainsworth backed his cart up, and after it had been loaded took it away. The Bench said that they regarded the thefts as exceedingly serious, and in particular with reference to John Ainsworth, as the receiver. He would be fined £10 and costs. The youths were bound over for twelve months.

Free Gas-Rings at Hipperholme.—The Solicitor to the Hipperholme Urban District Council called attention to a resolution of the Gas Committee that gas-rings or kettle-boilers should be supplied free to all prepayment consumers in the Council's gas area, and said there was a doubt as to whether it was advisable to act on this without ascertaining definitely from the Auditor that he would not take objection to such an expenditure of the funds. The Clerk replied that they were making inquiries of other undertakings; but he had no doubt they were all right. Should, however, anything occur in the way of a surcharge (which was very improbable), the Chairman of the Gas Committee would bear the cost. The Council were not giving these things, but only supplying them, under certain conditions, free of charge. Audits to-day were not conducted on the old lines.

Reading Gas Company's Employees' Dinner.

The new mess-room at the Reading Gas-Works presented a festive appearance on Saturday, the 18th inst., on the occasion of the eleventh annual dinner of the employees. The Engineer and Manager (Mr. D. H. Helps) presided. Mr. Hamilton Baker, the Assistant Engineer and Manager, proposed "The Chairman and Directors of the Reading Gas Company;" and in doing so referred to the fact that the building in which the dinner had taken place and the stokers' lobby were presented to the employees by the Directors in commemoration of the Company's jubilee. The toast was received with musical honours. Mr. Helps, replying on behalf of the Chairman and Directors, remarked that the past year had been a very eventful one in the Company's history, it being the fiftieth year of its existence. He could assure those present that when the Directors were considering how best to commemorate the jubilee, the thought which was uppermost in their minds was the welfare of the employees; and the result was that the club buildings and the stokers' lobby were enlarged, and all the men who had been one year in the Company's employ received a bonus. Some of them who had a number of years' service behind them received a nice little "nest-egg." No meeting of gas company employees at this time of year would be complete without reference to the honour conferred by the King upon the Governor of the Gaslight and Coke Company. They would remember that Sir Corbet Woodall honoured the jubilee celebrations of the Reading Gas Company by his presence; and he (Mr. Helps) was sure everyone in that room would be delighted with the King's appreciation of Sir Corbet's work. Then they must not forget their veteran Chairman, Mr. J. Okey Taylor, whose interest in the workers was as keen as ever. It was a very great pleasure to see Mr. Taylor at the works day after day; and though he had reached such an advanced age, they sincerely hoped he would be spared for many years to come. The toast of "The Chairman" having been honoured, Mr. Helps expressed his pleasure at attending the annual dinner. He thanked all present for their assistance during the past year, because it was only, he said, by each man doing his best that success could be achieved.

Public Health (Acquisition of Water) Bill.—A Bill bearing this title, which was introduced early in July last, by the Local Government Board, to give powers to local authorities in regard to the acquisition of water, and is still awaiting second reading, was the subject of a question to the Premier, on Monday night last week, by Mr. Peto, the Conservative Member for Devizes, who wished to know whether or not the measure would be proceeded with during the present session. Mr. Asquith said he feared this would not be possible. Under the Bill, the Board may, by Provisional Order, authorize a local authority, for the purpose of the acquisition of water, to abstract it from any river, stream, or lake; and a Provisional Order may be made, notwithstanding anything contained in sections 327 and 332 of the Public Health Act, 1875. Provision is to be made for compensation being given in respect of the abstraction of water under the Order.

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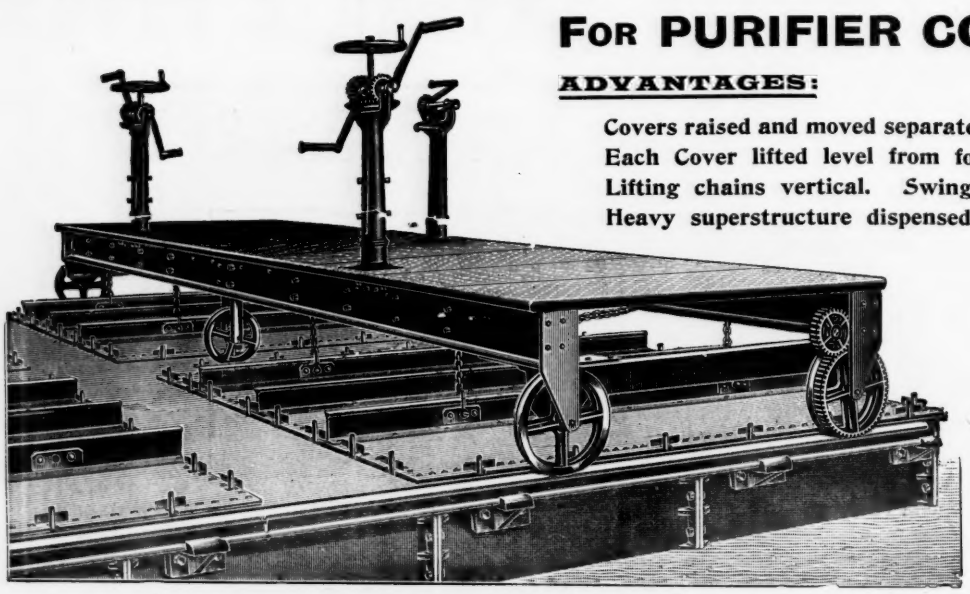

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Gas Developments at Thurles.—A letter was received by the Thurles (co. Tipperary) Urban District Council from the local Gas Company stating that, having now obtained a Provisional Order, they were taking steps to raise further capital with a view to developments; but that they feared it would be some months before they could have the money in hand, and they suggested that some member of the Council might be willing to advance £200 on a temporary loan at 5 per cent. Mr. Barry said he thought £9000 or £10,000 was required. It was decided to mark the letter as having been read.

New Storage Reservoir for Merthyr.—At their meeting on Monday last week, the Merthyr Corporation accepted the tender of Messrs. Robert M'Alpine and Co., of Westminster, at £232,000, for the construction of a storage reservoir at Pontsticill in the Taff Fechan Valley, Breconshire. The reservoir will be one of the largest in Wales. As designed, it will be nearly large enough to equalize the flow of the whole drainage area of 8350 acres. The earthen embankment will be 107 feet in height, and will cross the valley, which is about four miles above Merthyr, with a comparatively short length of about 1000 feet. The provision for overflow will consist of a shaft 16 feet in diameter. Water at the rate of 6,835,000 gallons per day will be discharged for compensation purposes. The reservoir will impound the waters of the Taff Fechan and its tributaries, and form a lake 2½ miles long. The undertaking will include the construction of a trunk main to convey the water to the southern boundary of the Merthyr county borough; it being the intention of the Corporation to supply water in bulk for the use of the Pontypridd Water Board, the Barry Urban District Council, the Rhymney and Aber Valleys Gas and Water Company, besides other authorities beyond the boundaries of their own area. The length of the pipe-line will be 15 miles. The total estimated cost of the scheme is about £500,000.

A company has been formed under the title of Strode and Co., Limited, with a capital of £20,000, in £1 shares (5000 preference), to carry on the business of mechanical, electrical, hydraulic, and general engineers and contractors, and to adopt an agreement with D. M. & G. W. Strode. The first Directors are D. M. Strode (Chairman), G. W. Strode, and A. E. Cumberbatch, each of whom may retain office while holding 100 ordinary shares. The registered office is 48, Osnaburgh Street, N.W.

A fire broke out last Wednesday afternoon in a portion of the extensive works of Messrs. Gwynnes, Limited, at Hammersmith. The building involved was constructed of corrugated iron and wood, with a glass roof, and was used as offices and testing-rooms, extending over an area of 90 ft. by 30 ft. According to the "Daily Telegraph," the cause of the fire is attributed to a defective electric circuit. It being daytime, the current was at once cut off, as there were eight or nine dynamos in the building, which was used for testing the powerful pumps manufactured by the firm.

The Lauriston Coal Company have been sinking pits for the purpose of discovering fire-clay, and have tapped a seam varying from 12 to 18 feet in thickness.

One of the neatest of the desk blotting-pads that have reached us this season is that of Messrs. Samuel Cutler and Sons, Limited. Externally there is no advertisement. Such advertisement as there is, is confined to occasional interleavings with the dated appointment pages at the head of the blotter. Under the cover of the appointment pages are some useful engineering memoranda.

To-morrow evening, in the City Chambers, Edinburgh, Mr. A. Canning Williams, Treasurer to the Edinburgh and Leith Corporations' Gas Commissioners, will deliver, under the auspices of the Institute of Municipal Treasurers and Accountants, a lecture on "The Books and Accounts of a Gas Undertaking." A series of diagrams will be used to illustrate the lecture.

Mr. R. J. Skinner, the Engineer, Manager, and Secretary of the Londonderry Gas Company, and Mrs. Skinner have lately sustained a bereavement in the loss of their elder son, Master Bryan Skinner. Deceased was a very popular pupil at Foyle College; and on the occasion of the funeral his school colleagues, who were accompanied by the Head Master (Mr. R. F. Dill, M.A.), walked in processional order. The coffin was borne by relays of the Company's workmen, who thus showed their respect for, and sympathy with, the bereaved parents.

At the London Bankruptcy Court, on the 17th inst., before Mr. Registrar Brougham, an adjourned application was made for the discharge of Jerome Walter May (trading as J. W. May and Co.), importer of gas lighting and other specialities, No. 33, Cock Lane, E.C. The previous proceedings were reported in the "JOURNAL" for the 24th ult. The statement of affairs disclosed liabilities expected to rank against the estate for dividend amounting to £8725. But the Trustee reported that proofs had been lodged to the total of £9277; and the assets, which in the statement were estimated to produce £1085, had only yielded £545—the difference being accounted for by the fact that the stock-in-trade, which was reckoned to produce £1010, had only brought in £421, and nothing further was likely to be realized. The Trustee further reported that a dividend of 9d. in the pound would probably be paid to the creditors. A barrister who appeared on behalf of the debtor stated that on the previous occasion the application was adjourned with a view to his consenting to judgment for a certain sum, or bringing the money into Court. The debtor's friends were willing to help him. But they could not do much; and it had been suggested that he should consent to judgment for £250, of which half should be paid down, and the rest in such a manner as the Court might direct. The amount now proposed was the utmost the friends could do, and, of course, the debtor would have to repay the money later on. The Registrar said that £250 would not be much to divide among creditors amounting to £9000, and he did not think he could accept the offer. The discharge would therefore be suspended for two years—this being the minimum period allowed by the Act.

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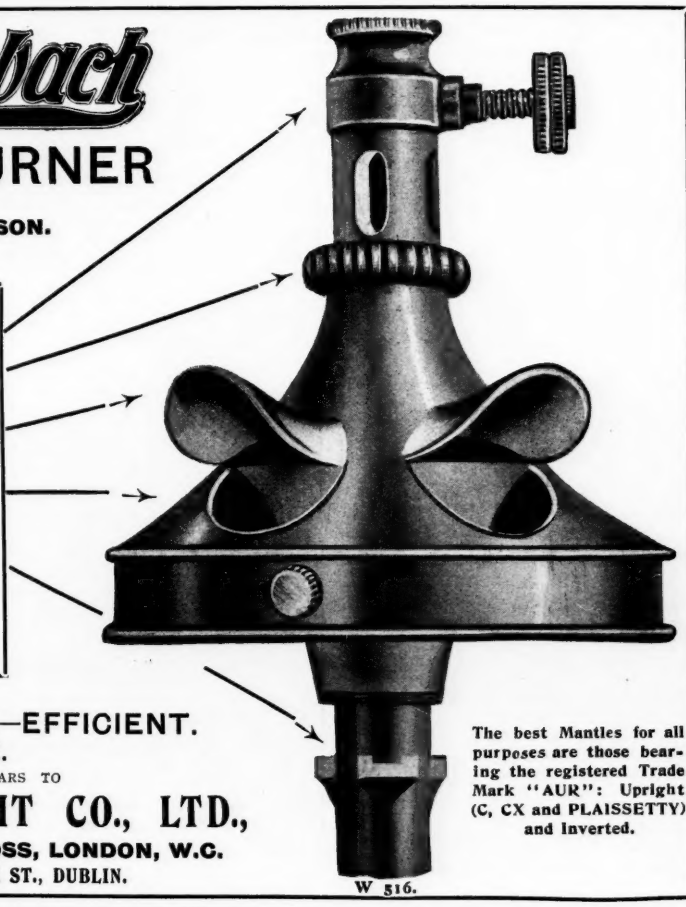

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The annual conference of the representatives of the Parkinson Stove Company, Limited, was held last Tuesday at the Imperial Hotel, Birmingham. Mr. William Cheshire (Director) presided, and was supported by Mr. F. R. Smith (another Director), of London; Mr. Percy C. Mawbey (the General Manager) being in the vice-chair. After the conference, dinner was served, followed by a musical evening, which was a great success.

A farmer named Young Lee, aged 62, was found dead in bed at the Wheat Sheaf Hotel, Ilkley, with the gas turned on and unlit; and at the inquest a verdict of "Accidental death" was returned. It appeared that deceased, who was on a visit to Ilkley, used oil-lamps at his farm, and so was unaccustomed to gas. The doctor called in said that the gas-tap turned easily; and he could well imagine a person whose fingers were not supple turning the tap off and then on again.

WANTED, FOR SALE, CONTRACTS, &c., ADVERTISEMENTS IN THIS WEEK'S "JOURNAL."

Appointments, &c., Vacant.

TRAVELLERS (Coal). No. 5693.
COSTS AND ESTIMATING CLERK. No. 5691.
STOKERS. Royal Small Arms Factory, Enfield Lock.
MAIN AND SERVICE LAYER. No. 5688.

Appointments, &c., Wanted.

CHARGE OF WATER-WORKS. No. 5689.

Books (Second-Hand) for Sale. No. 5685.

Plant, &c. (Second-Hand) Wanted.

RIVETED STEEL MAINS. No. 5692.

Meetings.

BOURNEMOUTH GAS AND WATER COMPANY. Offices, 90, Cannon Street. Feb. 21. 11.30 o'clock.
SOUTH SUBURBAN GAS COMPANY. De Keyser's Hotel. Feb. 14. Three o'clock.

TENDERS FOR

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MANCHESTER GAS DEPARTMENT. Tenders by Feb. 14.

Fire-Clay Goods.

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HALIFAX GAS DEPARTMENT. Tenders by Feb. 12.

Gasholder (Addition).

BARNOLDSWICK URBAN DISTRICT COUNCIL. Tenders by Feb. 3.

General Stores.—Oils, Paints, Lime, Gaskin, Ironmongery, Sulphuric Acid, Steel Goods, Brass Cocks and Lamp Fittings, Iron Valves, &c.

BARROW-IN-FURNESS CORPORATION. Tenders by Feb. 19.
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HALIFAX GAS DEPARTMENT. Tenders by Feb. 12.

Tar.

MANCHESTER GAS DEPARTMENT. Tenders by March 20.

NOTICES TO CORRESPONDENTS, ADVERTISERS, AND SUBSCRIBERS.

No notice can be taken of anonymous communications. Whatever is intended for insertion in the "JOURNAL" must be authenticated by the name and address of the writer; not necessarily for publication, but as a proof of good faith.

Subscribers who desire to avail themselves of the reduction in the Subscription by paying in advance for the Year 1913, are reminded that this can only be done during the current month.

Orders for Alterations in, or stoppages of, PERMANENT ADVERTISEMENTS should be received by the FIRST POST on SATURDAY.

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